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GREAT SCIENTIFIC DISCOVERIES

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FROM THE HOUSE OF MAGIC POT, THE WEEK, MANORAMA YEARBOOK, VANITHA & THE MALAYALA MANORAMA DAILY

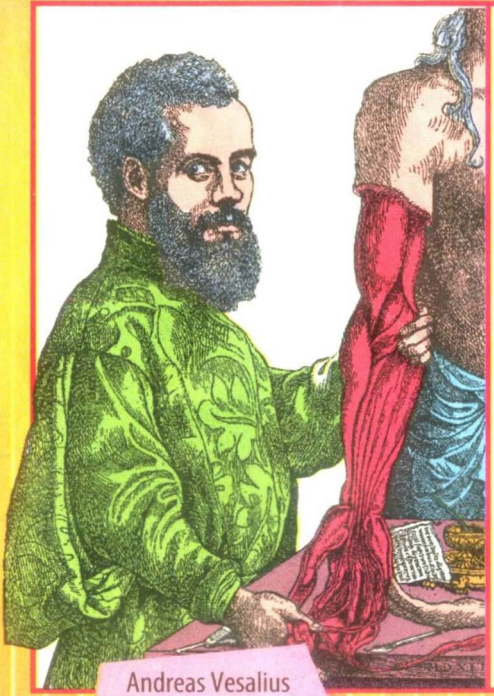
GROUNDBREAKING DISCOVERIES

What do you do when you catch a cold? The answer is quite simple. You take medication. If the cold turns to fever, the doctor will give you an antibiotic. This seemingly simple procedure was not known to the world till someone called Alexander Fleming discovered penicillin.

It is easy for us to take inventions like the telescope and microscope for granted, but these were landmark achievements of previous centuries which made our current scientific advancements possible. The world we live in is a work of science and technology.

This issue of *Tell Me Why* is a remembrance of some of the great scientific discoveries that changed the world, without which advancement of human life would not have been possible. It is a journey through the inspiring stories of several scientists whose perseverance and labour have influenced many aspects of our life.

GREAT SCIENTIFIC DISCOVERIES

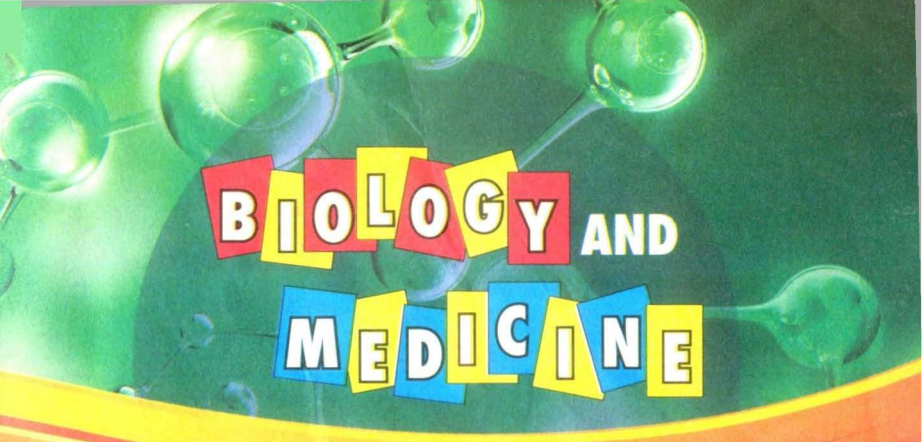


Andreas Vesalius

Why is Andreas Vesalius considered the founder of studies of modern human anatomy?

The work of ancient Greek physician Galen formed the basis of what doctors knew about human anatomy for centuries. However, Andreas Vesalius, a 16th century Flemish physician, approached the structure of the human body from a fresh perspective.

Until then, dissection



of human bodies was not used in the study of human anatomy; most of Galen's studies were based on dissection of animals. Unlike his predecessors, Vesalius dissected human bodies and conducted his studies through direct observation.

His discoveries were recorded and published in 1543 titled *De Humani Corporis Fabrica*, his masterpiece. This work revolutionized medical science and laid the foundation for research on modern human anatomy. Consequently, Vesalius came to be considered as the founder of studies on modern human anatomy.

Teacher to Physician

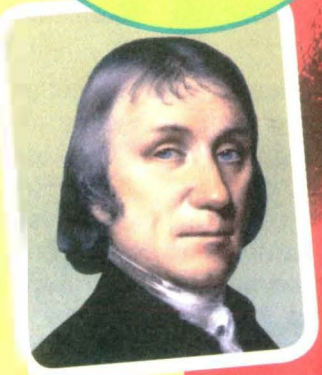
Andreas Vesalius was earlier a teacher. But he left teaching to become the court physician of Emperor Charles V. He even travelled with him during battles and diplomatic trips.

Why is the discovery of the human circulatory system important?

The fact that blood circulates in our body might seem obvious to us in this age of advanced medical technology, but that was not always the case Early knowledge of this subject came from the studies of Galen, the Greek physician. Unfortunately, most of his conclusions were later proven wrong.

Main Role

Joseph Priestley, Antoine Lavoisier and Jan Ingenhousz were the first to describe the role of oxygen in respiration and photosynthesis.



Joseph Priestley

It was William Harvey who discovered and published the first accurate description of the human circulatory system in 1616. Before Harvey's discovery, it was thought that blood was made in the liver which later turned into flesh. Though this might seem stupid to us, it was widely accepted by the doctors back then.

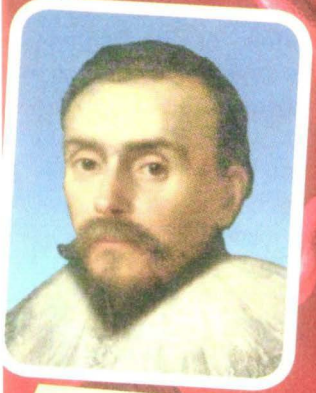
Harvey accepted only those ideas which had scientific evidence. He finally published his research findings in *Exercitatio Anatomica de Motu Cordis Sanguinis in Animalibus* (An Anatomical Exercise on the Motion of the Heart and Blood in Living Beings) in 1628. He proved that blood circulates within the body and that the circulatory system includes arteries, veins and the heart.

What are capillaries?

William Harvey's description of the circulatory system could not explain how blood moved from arteries to veins. This was one of the mysteries solved by the invention of the microscope.

In 1661, Marcello Malpighi was working in Bologna, Italy when he discovered tiny vessels through which blood travels. These tiny vessels known as capillaries could only be seen using a microscope and they proved to be the missing element in Harvey's theory.

Capillaries are the smallest blood vessels in the human body which function as the site of exchange for many substances. While substances such as water, oxygen and glucose exit the body, other items including, water, carbon dioxide, uric acid, lactic acid, urea and creatine enter the bloodstream through capillaries.



William Harvey

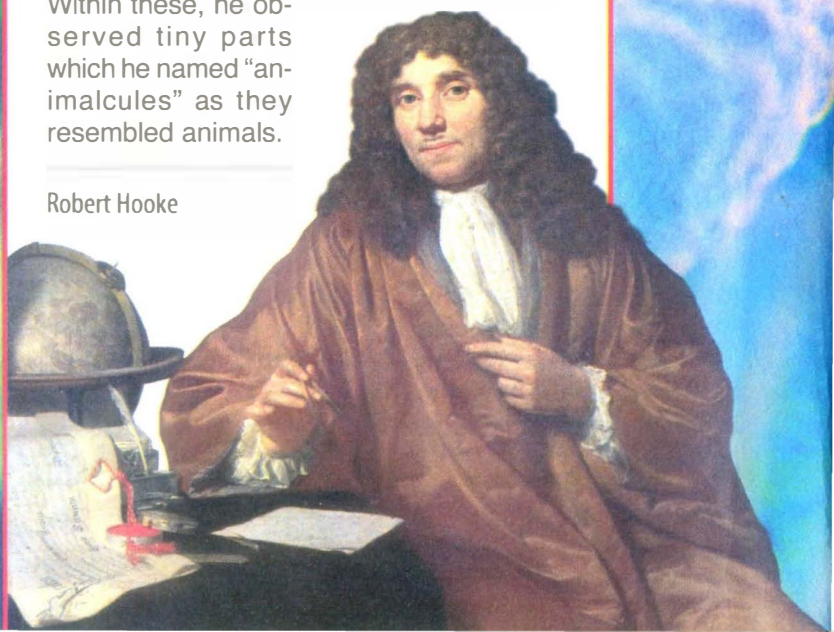
Who discovered cells?

What are the constituent elements of all living things? This centuries old question was answered only in the 1660s when scientists Anton Van Leeuwenhoek and Robert Hooke discovered cells and their parts.

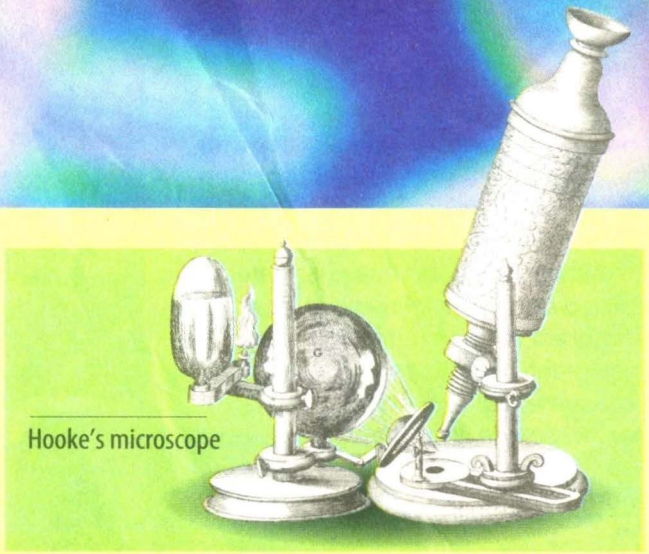
While observing a piece of cork, Hooke noticed that it was made of small structures that reminded him of individual rooms. What appeared like rooms to him were called cells. Meanwhile, Anton Van Leeuwenhoek studied substances such as blood and saliva under the microscope. Within these, he observed tiny parts which he named "animalcules" as they resembled animals.

First Ever

The first enzyme was discovered in 1833 by Anselme Payen. He called it diastase, whereas the term 'enzyme' was coined in 1878 by German physiologist Wilhelm Kuhne.



Robert Hooke



Hooke's microscope

Why is the discovery of microorganisms significant?

Robert Hooke and Anton Van Leeuwenhoek discovered the existence of microscopic organisms between 1665 and 1683. The presentation of the micro fungus Mucor in Hooke's *Micrographia* (1665) is the first published depiction of a microorganism. In 1674, Leeuwenhoek became the first person to see the tiny, single-celled protozoa that swim around in ponds and water butts.

The organisms discovered until then were comparatively larger than those like bacteria, which were even smaller than protozoa. In 1676, Leeuwenhoek made a lens that could magnify up to 280 times. Using this lens, he observed some of the larger types of bacteria collected from his mouth. Leeuwenhoek used certain techniques to watch them. These techniques probably involved lighting the microscopic organisms from a side, so that they would stand out like dust in a sunbeam.

What happens during photosynthesis?

We all know that plants cannot live without the sun. Plants around us absorb energy from sunlight to make food from water and carbon dioxide. This process is called photosynthesis. Though this phenomenon has existed since time immemorial, humans were ignorant about it until the 1800s.

When green plants receive sunlight, they consume higher amount of carbon dioxide than they release. Moreover, they give out more oxygen than they take in.

When it is dark, they use oxygen and release carbon dioxide like any other animals and humans.

This process was first described by the Dutch doctor Jan Ingenhousz in 1779 in his book 'Experiments Upon Vegetables, Discovering Their Great Power of Purifying the Common Air in Sunshine, and of Injuring it in the Shade and at Night.'

Jan Ingenhousz

The general equation for photosynthesis is:

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 + 6\,O_2$$

Where CO_2 is carbon dioxide, H_2O water, $C_6H_{12}O_6$ glucose and O_2 oxygen.

Why is the discovery of smallpox vaccine significant?

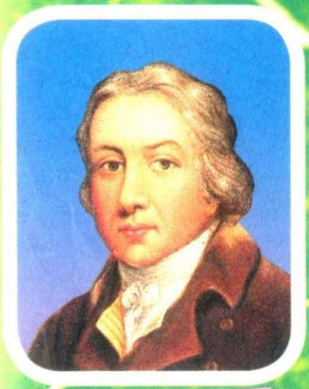
Smallpox was a deadly viral infection that was common around 200 years ago. The virus spread like wildfire and killed many people.

The disease didn't have any cure until Edward Jenner, a British surgeon, found out something strange. Jenner noticed that people who caught a similar but milder disease called cowpox were immune to smallpox. In 1796, he scratched a boy's skin and applied fluid from a girl with cowpox. The boy later survived deliberate smallpox infection. This was the world's first vaccine.

We were all given vaccines during different periods of our life; vaccination against diphtheria, chicken pox, TB and so on. Have you ever wondered why?

When our bodies are afflicted by certain viruses or foreign entities, it creates different antibodies to destroy the invaders. But serious infections can often overwhelm the system by the time the correct antibodies are produced.

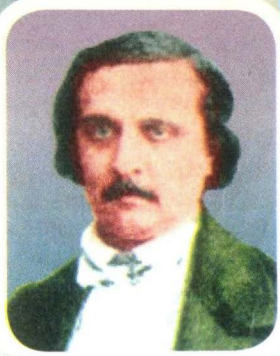
It was found that advanced warning in the form of harmless vaccines helps to resolve this issue.



Edward Jenner

Do you know?

The Rh factor in human blood was identified by Dr Alexander S. Wiener and Karl Landsteiner in 1940.



Charles Frederic Gerhardt

BAYER
One Real Aspirin
Counterfeits and substitutes may be ineffective, and even harmful. Refuse them. Protect yourself by demanding
Bayer-Tablets of Aspirin
Every tablet and every package of genuine Aspirin bears
"The Bayer Cross"
Your Guarantee of Purity

When was aspirin isolated?

None of us like to suffer pain. Several home remedies were tried and tested since time immemorial to find substances that would alleviate pain. After a considerable number of trials, a French chemist called Charles Henri Leroux isolated the miracle drug salicylic acid in 1829. This drug could relieve pain and fever. The process of its isolation was later improved by an Italian, Raffaele Miria in 1838.

In 1853, Charles Frederic Gerhardt buffered salicylic acid with an extra acetyl group to create acetylsalicylic acid, the true aspirin. However, true aspirin was soon forgotten. Its more recognisable tablet form was created by Felix Hoffmann, a German chemist.

Gerhardt's findings were rediscovered by Hoffman who later patented it. He also managed to solve many of the problems associated with earlier preparations. For instance, previously when administered with salicylic acid, patients used to experience severe nausea and vomiting. In the late 19th century, when the pharmaceutical company Bayer realised the potential of aspirin they bought its patent and began mass production.

Who propounded the cell theory?

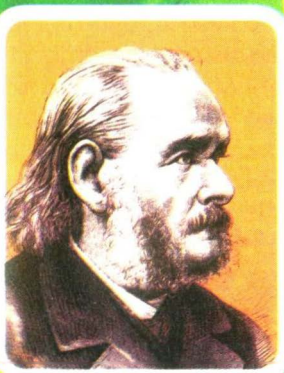
Though Robert Hooke coined the term 'cell', Theodor Schwann and Matthias Jakob Schleiden are accredited with the first cell theory for their work in the 1830s.

The cell theory states that living things are composed of cells, be it unicellular or multicellular; cells are the basic unit of life and cells arise from existing cells. Although Schleiden and Schwann proposed that cells arise through spontaneous generation, this was proven wrong.

The accepted tenets of modern cell theory are as follows:

1. Cells are the fundamental units of structure and function in all living things.
2. All organisms are made up of one or more cells.
3. Cells arise from pre-existing cells through cellular division.

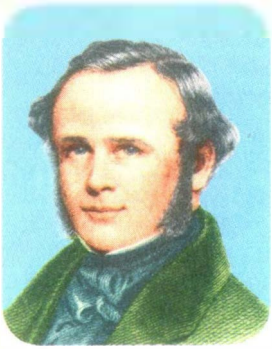
Theodor Schwann



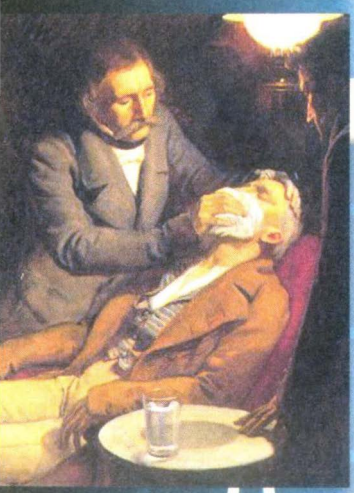
Matthias Jakob Schleiden

Tissue

Groups of cells of the same type are called tissues.



Horace Wells



First use of anaesthetics by William Morton

When did anaesthetics come into use?

In the olden days, surgeries and other medical treatments were conducted without administering pain killers. The patient had to suffer severe pain to get the treatment done. Surgeons and doctors worked to discover sedatives that would numb the patient's body, so that the surgery would be painless, or rather less painful.

Two American dentists, Horace Wells and William Morton were the first to use anaesthetics. Wells made an unsuccessful attempt to use laughing gas (nitrous oxide) in 1845 in addition to trying if ether would act as a local anaesthetic. Morton tried making his patients inhale ether and successfully demonstrated anaesthetic surgery in 1846.

Next year, a Scottish surgeon James Simpson started using chloroform to help women through the pain of childbirth. He attained immense popularity after giving chloroform to Queen Victoria during the birth of Prince Leopold, her eighth child.

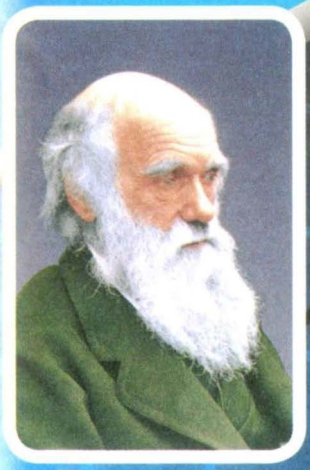
Much safer and effective alternatives to sulphuric ether and chloroform are available today. Mainly sevoflurane and isoflurane are used as anaesthetics. General anaesthesia is considered as one of the greatest discoveries of all time.

Why is Charles Darwin an important figure in science?

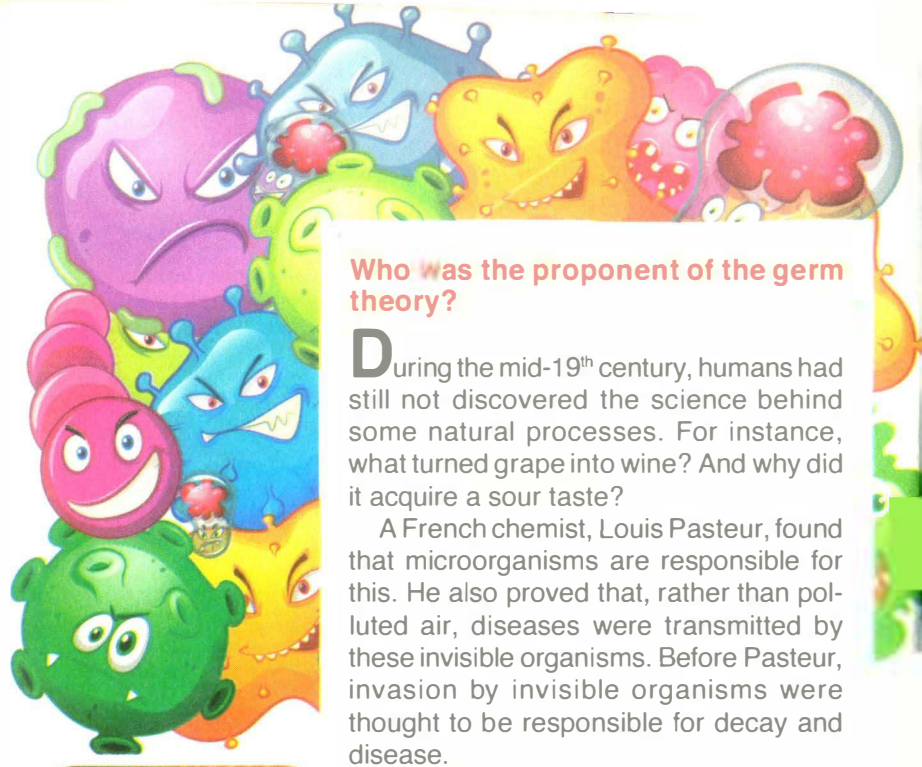
In the year 1859, Charles Darwin, a doctor's son, shook the world with the publication of a book. The book, titled, *On the Origin of Species*, claimed with supporting evidence that plants and animals evolved from earlier forms and are still evolving. Darwin's work opposed the belief that animals and plants were created as we see them today.

His theory of evolution is based on the idea of natural selection. Though the members of a species have many similarities, each one is slightly different from the other. The differences that some members possess help them survive by competing with the others. And the traits that helped them survive are passed on to their offspring.

Darwin observed the differences between the finches on various Pacific Islands and studied fossil records. The concept of natural selection came to him after reading an essay by Thomas Malthus in which Malthus said that animals compete to survive. Darwin realised that such a competition can explain the evolution of animals.



Charles Darwin

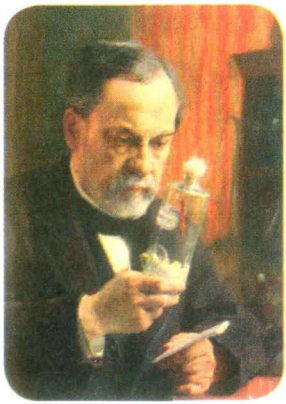


Who was the proponent of the germ theory?

During the mid-19th century, humans had still not discovered the science behind some natural processes. For instance, what turned grape into wine? And why did it acquire a sour taste?

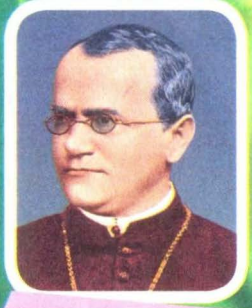
A French chemist, Louis Pasteur, found that microorganisms are responsible for this. He also proved that, rather than polluted air, diseases were transmitted by these invisible organisms. Before Pasteur, invasion by invisible organisms were thought to be responsible for decay and disease.

In 1864, the French Academy of Sciences officially accepted Pasteur's conclusions. Three years later he was provided with his own laboratory in France's *Ecole Superieure*, a graduate school in Paris. Pasteur's 'germ' theory soon received wider acceptance. He revolutionised medicine and the food industry by establishing the reality of germs. He also developed the earliest vaccines against fowl cholera, anthrax, and rabies. Pasteur became a household name after he invented the technique for treating milk and wine to prevent bacterial contamination. This process is now called pasteurization.



Louis Pasteur in his lab

Hugo De Vries



Gregor Mendel

Who formulated the laws of inheritance?

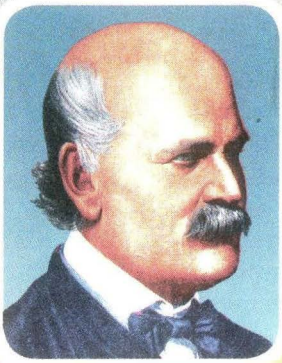
"You look exactly like your mother!" "Like father like son." Most of us might have heard comments like these. It is true that we resemble our parents. But why is it so? Because we inherit certain traits from them.

The fundamental laws of inheritance were discovered by Gregor Mendel. Through his work on pea plants, he deduced that genes come in pairs and are inherited as distinct units, one from each parent. For example, a man and a woman both with brown eyes, could have a one-in-four chance of producing a child with blue eyes. Mendel published his discoveries in 1865 after spending eight years doing genetic experiments on pea plants. However, his work was disregarded by a vast majority.

It was Dutch botanist Hugo De Vries who realised the importance of Mendel's discoveries in 1900. Many rules of heredity were established by Mendel's experiments and are now referred to as the laws of Mendelian inheritance. He gained recognition as the founder of the modern science of genetics posthumously.

Switch to Meteorology

Gregor Mendel established the Austrian Meteorological Society in 1865. More of his writings were about meteorology than about biology.



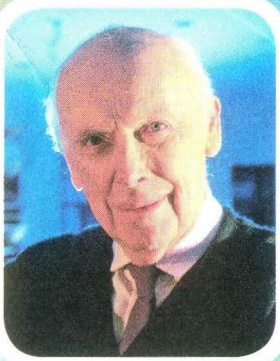
Ignaz Semmelweis

Who discovered antiseptics?

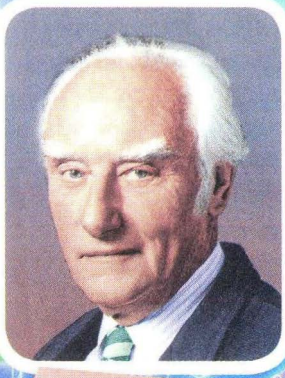
A Hungarian doctor named Ignaz Semmelweis once asked the medical students at Vienna's maternity hospital to disinfect their hands. He had proved that this made their presence in labour rooms less dangerous. But this offended his superiors and he was dismissed from service.This happened in 1849.

The indifferent attitude towards disinfecting continued well after 1864 when Louis Pasteur's germ theory was accepted in France. Most surgeons continued operating without even changing into clean clothes.

However, things began to change in 1867 when Joseph Lister published the paper "Antiseptic Principle of the Practice of Surgery". Lister was inspired by Louis Pasteur's germ theory of putrefaction. He advocated the use of carbolic acid, which is a powerful germ killer to disinfect. He had already begun putting this into practice in his operating theatres and on to dressings by 1865. Lister's introduction of antiseptic surgical methods paved the way for modern sterile surgery.



James Watson



Francis Crick

Naming

The current name of DNA- deoxyribonucleic acid, was given by Albrecht Kossel in 1881.

How was the presence of DNA discovered and by whom?

There is a lot of confusion as to who actually discovered DNA. Though many give credit to James Watson and Francis Crick for discovering DNA in the 1950s, the actual discovery occurred decades before that.

Watson and Crick came to their monumental conclusion about the structure of DNA in 1953 by building up on the work of pioneers before them.

The molecule now known as DNA was first identified in the 1860s by the Swiss chemist, Johann Friedrich Miescher who called it 'nuclein'.

Although the significance of this discovery was not initially recognised, it set further research and discoveries in motion. In the 1880s, Albrecht Kossel isolated the five organic compounds that are present in nucleic acid: adenine, cytosine, guanine, thymine and uracil.

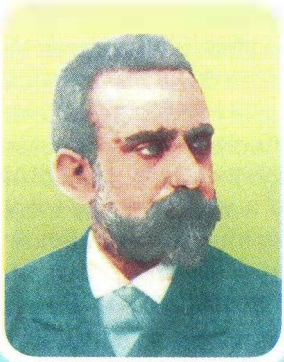
The role of DNA in heredity was confirmed in 1952, when Alfred Hershey and Martha Chase showed through experiments that DNA is genetic material.

When was cholera vaccine discovered?

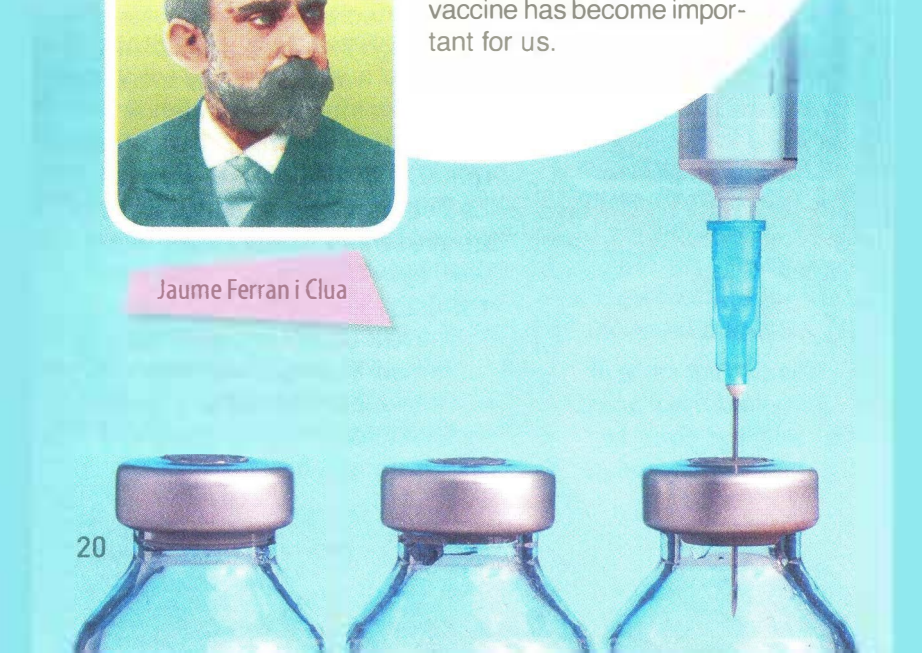
The first vaccine for cholera was developed in the late 19th century. It became the first widely used vaccine ever made in a laboratory. In 1885, Jaume Ferran i Clua developed an early version of this with a live vaccine he isolated from cholera sufferers in Marseilles.

Waldemar Haffkine later developed another cholera vaccine with milder side effects and tested it in Calcutta between 1893 and 1896.

The first heat-killed cholera vaccine was developed by Wilhelm Kolle in 1896. Much easier to make, Kolle's vaccine was used on a large scale in Japan in 1902. Recognised by the WHO as an essential medicine, cholera vaccine has become important for us.



Jaume Ferran i Clua

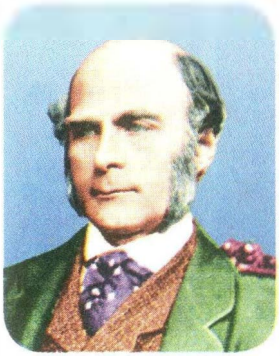


Who discovered that each fingerprint is unique?

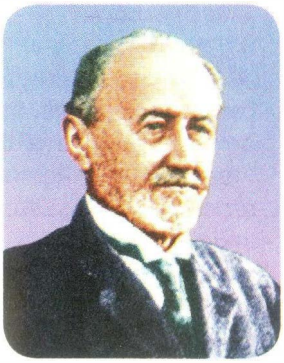
Fingerprints have been found on ancient Babylonian clay tablets. They are excellent in establishing the identity of individuals and hence widely used to track down criminals. However, this is only possible because they have been systematically classified, making it easy to compare new prints with the ones on record.

British scientist Francis Galton devised a basic classification after confirming that every fingerprint is different. Galton estimated that there is only 1 in 64 billion chance of a false positive, which happens if two individuals have the same fingerprint. An Argentine police officer named Juan Vucetich created the method of recording the fingerprints of individuals on file by studying Galton's pattern types. He set up the world's first fingerprint bureau in 1892.

A fingerprint bureau was established in Kolkata in 1897. Azizul Haque and Hem Chandra Bose were the two fingerprint experts in Kolkata. They co-devised a system that became popular. It was named the Henry Classification System, after their supervisor Edward Henry.

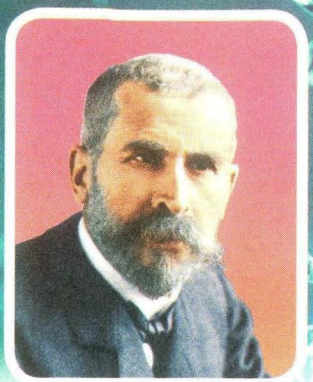


Francis Galton



Juan Vucetich

Alexandre Yersin



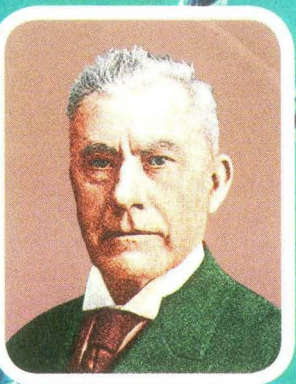
Emile Roux

What is an antitoxin? Who discovered it?

When people recover from bacterial illnesses, they often develop antitoxins that give them immunity against recurrence of the disease. An antitoxin is an antibody with the ability to neutralise a specific toxin.

One of the most popular antitoxins is the diphtheria antitoxin. In 1888, Emile Roux and Alexandre Yersin showed that the toxins produced by the Corynebacterium diphtheriae causes symptoms of diphtheria in animals. Two years later, the first antitoxin to diphtheria was made when Shibasaburo Kitasato and Emil von Behring immunised guinea pigs with heat-treated diphtheria toxin. Behring received the Nobel Prize for Physiology or Medicine in 1901.

It is believed that the diphtheria antitoxin was first used to treat a diseased human in 1891. Today antitoxins are used in the treatment of botulism, diphtheria, dysentery, gas gangrene and tetanus.



Martinus W. Beijerinck

Saviour

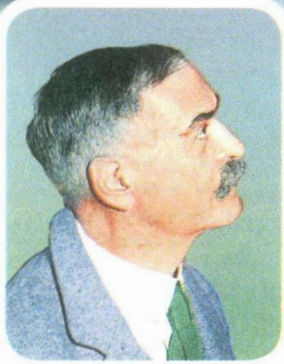
Penicillin was the first antibiotic that doctors used. It was Alexander Fleming who is credited with its discovery. Less than 1 per cent of people are dangerously allergic to penicillin.

Alexander Fleming

Who discovered the role of viruses in diseases?

Russian microbiologist Dmitry Ivanovsky was the first to realise that bacteria were not the only infective agent. Ivanovsky published a paper on a virus infection of tobacco plants in 1892. However, Ivanovski probably did not grasp the full meaning of his discovery. Martinus W. Beijerinck, in 1898 became the first one to use the term 'virus' to indicate the microorganism causing tobacco mosaic disease.

A virus is an infectious particle that can multiply only inside a living cell. Since it is made of only a set of genes wrapped in protective covering, a virus takes over a plant or animal cell and forces it to replicate the invader. Both Ivanovsky and Beijerinck discovered that viruses were smaller than bacteria and invisible under an ordinary microscope. These two scientists brought significant and complementary contributions to the discovery of viruses. The discovery of tobacco mosaic virus stands out as a milestone in the history of virology.



Karl Landsteiner

Who discovered the ABO blood group system?

Many aspects of the human body remained unclear to us till the advancement of medical science. The reason why certain blood transfusions were successful while others could be deadly was discovered only in 1900 by Karl Landsteiner at the University of Vienna. He discovered the ABO blood group system by mixing the red cells and serum of each of his staff. Landsteiner demonstrated that serum of some people agglutinated or caused clumping of red blood cells of others.

From these early experiments, he identified three blood groups which he called A, B, and C. The last one was later renamed 'O' from the German term 'Ohne' which means 'without', similar to 'zero' or 'null' in English.

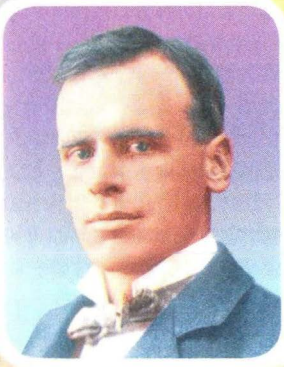
The fourth blood group AB, which is rarer than the others, was discovered a year later. Landsteiner was awarded the Nobel Prize in Physiology or Medicine in 1930 for his work.

Who discovered the hormones?

Hormones are chemicals such as adrenaline, which control our body and causes our heart to pound in times of stress.

The first hormone was discovered in 1902 by William Bayliss and Ernest Starling, two British physiologists (people who study how living things work). They found that when food reaches the stomach, a chemical is released into the bloodstream, making the pancreas secrete digestive juices. They called this chemical secretin. The term 'hormone' was later coined by Starling.It is derived from the Greek expression meaning 'setting in motion'.

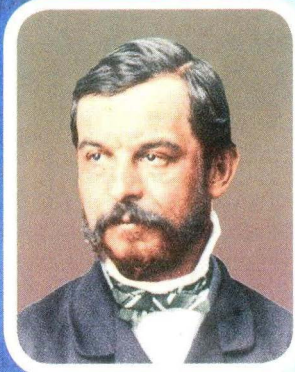
Physiology made a great leap when Bayliss and Starling introduced the concept of hormone with recognition of chemical regulation three years later. Even today, our understanding of hormones is a work in progress.



Ernest Starling

Vitamin K

Vitamin K was discovered by Henrik Dam in 1929.



Wilhelm Hofmeister

What is the relevance of the chromosome theory of inheritance?

Wilhelm Hofmeister first observed chromosomes during cell division, as early as 1848. However, the chromosome theory of inheritance is credited to two individuals: the papers by Walter Sutton in 1902 and 1903, and to the independent work done

When were vitamins discovered?

Our body requires vital elements including carbohydrates, proteins, minerals, fats and vitamins. The discovery of vitamins was a major scientific achievement in our understanding of health and diseases. Research flourished between early 19th century and mid-20th century resulting in plenty of discoveries.

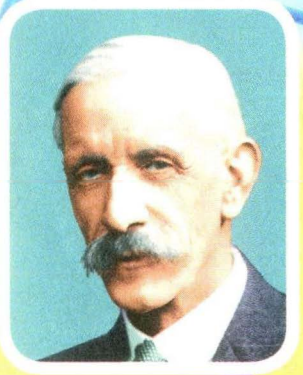
British biochemist Frederick Hopkins conducted an experiment on rats by feeding them an artificial mixture of the known constituents of milk such as carbohydrates, proteins and fat. He found that rats died when they were fed the mixture of these ingredients, but thrived when fed real milk. Hopkins concluded that to grow, animals need another substance in their diet that was described as accessory factors.

In 1912, Polish biochemist Casimir Funk identified one of these in rice. On finding that it was a chemical called an amine, he proposed the name 'vita-

around the same time by Theodor Boveri.

In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes. Chromosomes are only visible during cell division.

The chromosome theory of inheritance is the fundamental unifying theory of genetics which identifies chromosomes as the carriers of genetic material. The theory states that chromosomes are the basis for all genetic inheritance. Chromosomes are seen in all dividing cells and pass from one generation to the next.

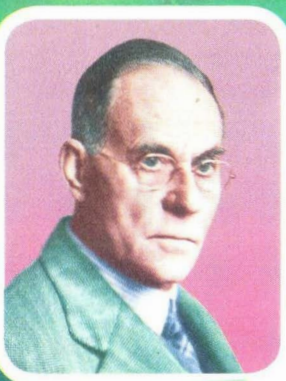


Frederick Hopkins

mine'. Though all vitamins are not amines, the name Funk suggested was adopted after removing the 'e' from the end.

Global Initiative

The World Health Assembly's Global Polio Eradication Initiative was launched in 1988 with the support of key health organisations.



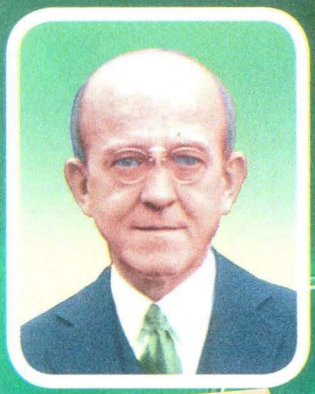
Leonard Colebrook

Gerhard Domagk

Why is the discovery of sulphonamide drugs crucial?

Before the use of antibiotics, sulphonamides were the only drugs that could kill a wide range of bacteria. In 1932, German bacteriologist Gerhard Domagk discovered the first prontosil, a non-antibiotic anti-bacterial drug. Scientists later realized that this broke down in the body to give a more potent drug, sulphanilamide.

From 1936, after clinical trials by British doctor Leonard Colebrook, several sulpha drugs were used to save thousands of lives. They are still used when antibiotics are ineffective. For his remarkable achievements in the fight against infections, Domagk received the Nobel Prize for Medicine in 1939.



Oswald Avery

Who discovered the double helix structure of DNA?

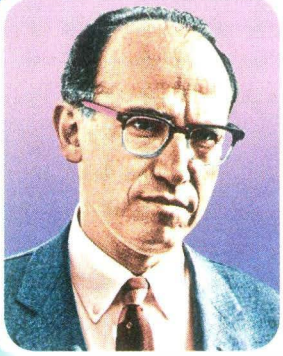
The assumption that the nucleic acid in DNA carries genetic information was proved by Oswald Avery by 1943. However, no one could explain how it worked. By the early 1950s, two groups of scientists were on the verge of a breakthrough regarding this.

At King's College in London, Rosalind Franklin and Maurice Wilkins were studying DNA using X-ray diffraction as the primary tool. James Watson and Francis Crick however, made crucial advance by proposing that the DNA molecule was made up of two chains of nucleotides paired to form a double helix, like a spiral staircase.

The double helix structure of DNA was discovered by Watson and Crick in 1953. Double helix refers to the structure formed by double-stranded molecules of nucleic acids and this structure was first published in the journal *Nature* in 1953.

First Ever

The first cloning of an animal was done in the 1880s by German biologist Hans Driesch who cloned a sea urchin from an embryo cell.

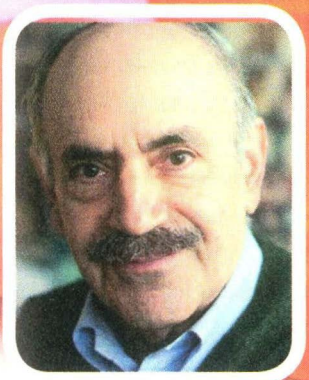


Jonas Salk

Why is the discovery of polio vaccine a milestone?

Poliomyelitis, or polio is a viral infection that can cause paralysis. It remained a widespread threat until the US physician Jonas Salk developed polio vaccine. It was first successfully used at a trial in 1952 and the Salk vaccine finally received approval in 1955 after further trials.

The more commonly used vaccine against polio that is administered orally was developed by a Polish-US physician Albert Sabin. The vaccine contains weakened polio virus that builds immunity without harming the body. As one of the most necessary medications required in a basic health system, it has been added to WHO's list of essential medicines.

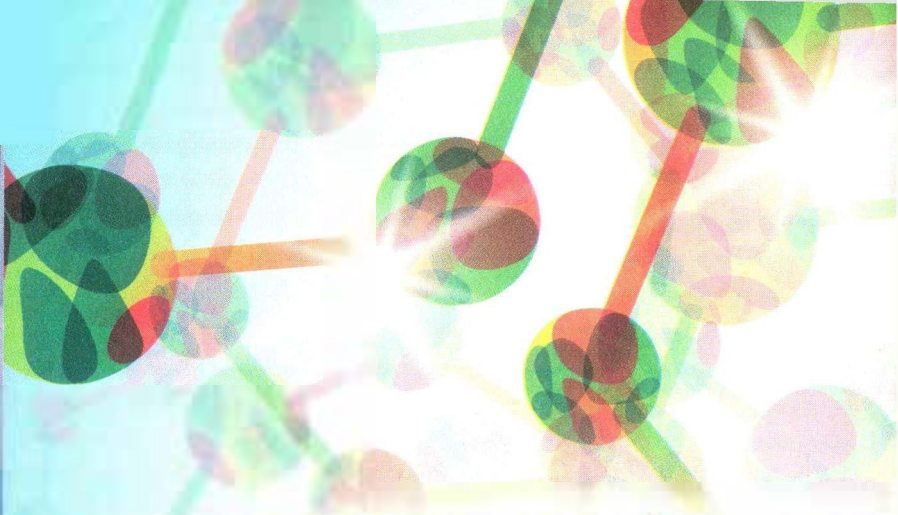


Prof. Robert Weinberg

When were oncogenes first discovered?

Oncogenes are genes with the potential of causing cancer. Human oncogenes were first discovered by multiple US research teams in 1981. One research team consisted of Prof. Robert Weinberg at the Centre for Cancer Research which is part of the Massachusetts Institute of Technology. Another one was that of Dr. Geoffrey Cooper at the Sydney Farber Cancer Institute, in Boston.

Oncogenes do not generate cancer by themselves, but do so under the influence of carcinogens, or ionising radiations. Research has isolated cancer genes associated with cancer of different parts like colon, bladder, and kidneys.

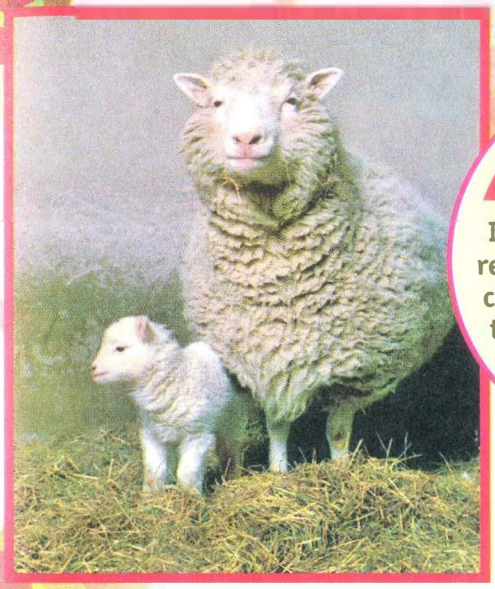


When was HIV identified as the reason behind AIDS?

The link between AIDS and HIV was established in 1983. Human Immunodeficiency Virus (HIV), identified in the 1980s are a group of viruses called retroviruses. Available evidence shows that it affected humans sometime in the late 19th or early 20th century during hunting and butchering of primates. A particular type of chimpanzees in West Africa has been established by scientists as the source of HIV infection in humans.

The earliest known case of HIV-1 infection of a human was found in 1959 from the blood sample of a man from Kinshasa, Democratic Republic of the Congo.

Identifying and diagnosing HIV is the first step in availing proper treatment. Implementing identification strategies are crucial to improve quality of life of infected individuals and reduce infant and child mortality due to HIV, particularly in sub-Saharan African nations and all around the world.



Chinese Glory

In 1963, Chinese scientists reportedly created the first cloned fish by transferring the DNA from a male carp into the egg of a female carp.

What made Dolly, the sheep, famous?

Dolly is the first mammal to be cloned from an adult cell and this made her the world's most famous clone. A clone has the same DNA sequence as its parent and therefore, it is genetically identical. Researchers claimed that they had used a mammary gland cell for cloning Dolly.

In the previous attempts at cloning of animals such as frogs, mice, and cows, DNA from embryos had been used.

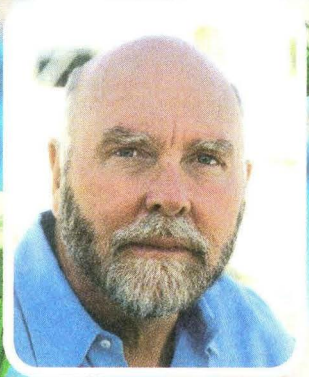
Dolly was cloned at the Roslin Institute in Scotland and lived there until her death in 2003 at the age of six.

Have the human genomes been sequenced completely?

The human genome is a human being's complete set of genes contained within a sequence of chemical units (adenine, cytosine, guanine or thymine) unique to humans. At present, no human genome has been sequenced completely.

A draft of the genome sequencing was announced by two rivals- the public Human Genome Project (HGP) led by Francis Collins, and the private Celera Genomics, led by Craig Venter- on 26 June 2000. Neither of these genome sequencing projects was completed. HGP has progressed lesser than the other but permits the public to see their result free of cost whereas, Celera charges people for access. As of February 2004, relatively more information was published by both organisations.

Though the work is not complete, researchers have sequenced over a million human genomes by late 2018.



Craig Venter

Number Game

There are between 30,000 and 40,000 genes in the human genome.

Does the discovery of the atom date back to 450 BC?

The quest to find indivisible particles of matter started as early as 450 BC with the Greek philosopher Democritus. He wondered what would happen if one kept on cutting an apple into smaller pieces. He named those final pieces which could not be cut anymore 'atomos'. The modern name atom comes from this.

Democritus

British Chemist John Dalton revived the ideas of Democritus in the1800s. He developed Dalton's atomic theory from his research. It states:

a) All substances are made of atoms. b) Atoms are the smallest particles of matter which cannot be divided further. c) Atoms can neither be created nor be destroyed. d) All the atoms of an element are alike and have the same mass. Atoms of different elements have different masses. e) Atoms join together to form compounds and a given compound always consists of the same kinds of atoms in the same ratio.

Dalton's theory was accepted worldwide. However, Dalton's idea that atoms are the smallest particle was disproved with the discovery of protons, neutrons and electrons.

When was methanol first discovered?

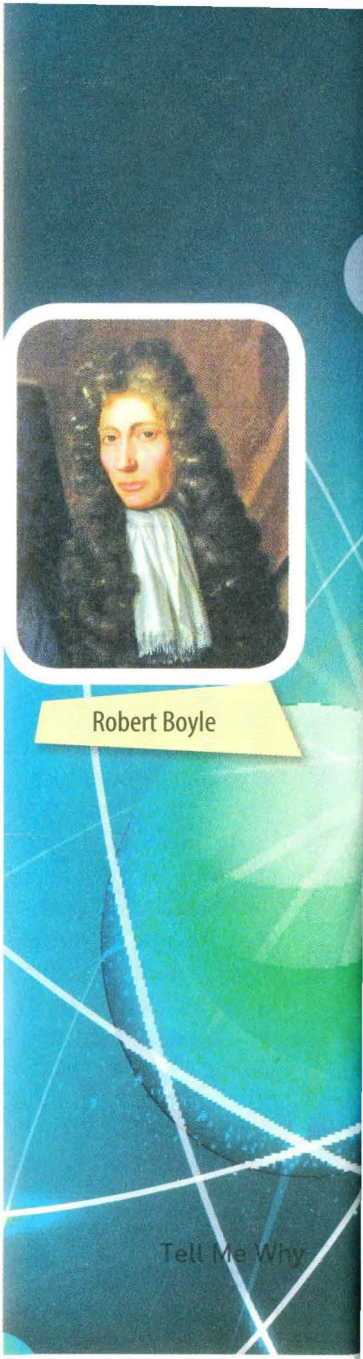
Methanol also known as methyl alcohol, wood alcohol, or wood spirit was formerly produced by the destructive distillation of wood, that is, the decomposition of wood by heating it in the absence of air.

It has been in use since ancient times. For instance, methanol obtained from wood was one of the different substances used by ancient Egyptians for embalming. This clear, flammable, and toxic liquid can cause blindness, if repeatedly inhaled or ingested.

The older names for methanol such as spirit of wood and wood alcohol came into use because it is a by-product of distillation of wood, a process discovered by an Irish chemist named Robert Boyle. He synthesised pure methanol in 1661.

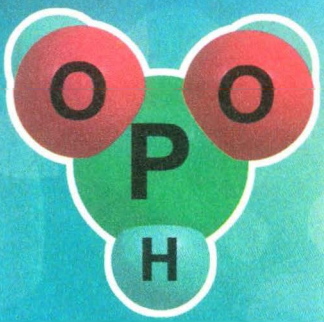
Nowadays, carbon monoxide gas is combined directly with hydrogen in the presence of a catalyst for methanol preparation. However, syngas, which is a mixture of hydrogen and carbon monoxide derived from biomass, is more commonly used for methanol production.

Pure methanol is an important material in chemical synthesis. It is used in rocket fuel and added to fuel mixtures to stretch the life of gasoline.



Isotopes

Isotopes are atoms that have the same number of protons and electrons but a different number of neutrons. For example, isotopes of hydrogen are 1H-Protium, 2H-Deuterium and 3H-Tritium.



Who discovered phosphorus?

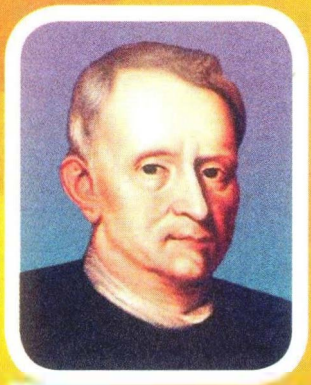
In 1669, a chemist named Hennig Brand in Germany prepared a luminous substance from urine. He called it 'cold fire' as it glowed in the dark. This substance was phosphorus.

The name phosphorus is derived from the Greek word 'phosphoros', which means "bringer of light."

Like other non-metals, pure phosphorus can assume different forms. There are several phosphorus allotropes. Four common forms are white, red, violet, and black phosphorus. Brand had discovered white phosphorus. He was extremely secretive about the method he used to produce phosphorus from urine. Ultimately, he sold the recipe to D. Krafft, a commercial agent from Dresden, Germany. A few years later, Johann Kunckel in Sweden managed to make phosphorus. Robert Boyle in London followed suit.

The forerunner of modern matches was first introduced by Robert Boyle who used phosphorus to ignite sulphur-tipped wooden splints in 1680.

Phosphorus is essential for life. It is a component of DNA, RNA, ATP, and phospholipids. Phosphate also serves as a great fertiliser.



Jan Baptist van Helmont

When was carbon dioxide first isolated?

Carbon dioxide was the first gas to be identified as a component of the air around us. Its effects were observed long before scientists understood the function of carbon dioxide.

Around 1640, the Flemish scientist Jan Baptist van Helmont discovered that air was not composed of a single substance as previously understood and there were vapours different from air. He coined the term 'gas' to describe these vapours.

The gas given off by burning wood was collected, and Helmont called it 'gas sylvestre'. It was later understood that this gas was carbon dioxide.

A more substantial study of carbon dioxide was done by the British chemist Joseph Black through systematic investigation. In 1756, Black discovered that heating carbonates resulted in the release of carbon dioxide. In 1783, French physicist Pierre Laplace demonstrated that oxygen from the air is used to burn carbon stored in the body and produce the carbon dioxide in exhaled breath.

Man-made Atom

Technetium which has 43 protons is the first atom to be made by Man.

Who discovered hydrogen?

Robert Boyle had synthesised hydrogen gas while experimenting with iron and acids in 1671.

However, it was recognised as a distinct element only in 1766 by Henry Cavendish. Hydrogen gas was produced when Cavendish dissolved metal in sulphuric acid. He first found that hydrogen is lighter than any other gas. Later, he confirmed that hydrogen forms water when it burns. This property inspired the French chemist Antoine Lavoisier to use the Greek term 'hydrogen' which means 'water maker' to describe it.

Antoine Lavoisier

Found abundantly in living matter, plants and animals, hydrogen is one of the most important elements. Hydrogen is found almost everywhere.

We have it all around us in the form of water, fats and proteins. But it is also found in stars and giant planets. Even the sun is mostly made up of hydrogen. Inside the sun and other stars, hydrogen atoms are converted to helium atoms due to intense pressure. This process is called fusion.

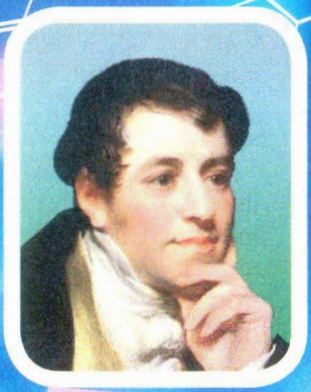
Hydrogen is used to make ammonia for fertilisers. In rocket fuel, liquid hydrogen is combined with liquid oxygen to produce a powerful explosion.

Who coined the term laughing gas for Nitrous Oxide?

Joseph Priestley discovered a gas in the late 1770s. Sir Humphrey Davy became the first human to inhale it and described it "very pleasurable" and called it 'laughing gas.' This gas was nitrous oxide. Priestley's discoveries were published in 1772 in the book *Experiments and Observations on Different Kinds of Air.*

Though Davy discovered that inhaling nitrous oxide could relieve a conscious person from pain, its primary use still remained recreational. These nitrous oxide capers occurred in travelling medicine shows and carnivals where the public paid a small price to inhale a minute's worth of gas. People would laugh and act silly until the effect of the drug ended abruptly, leaving them confused.

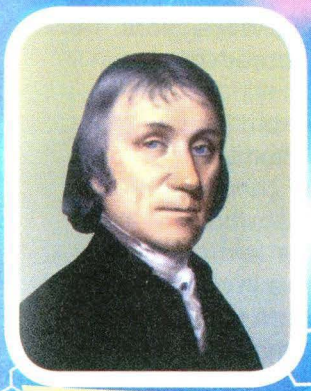
It wasn't until another 44 years had gone by, that doctors began to use it for anaesthesia. In the early 1840s, nitrous oxide was used as an anaesthetic in clinical dentistry and medicine.



Sir Humphrey Davy

Do you Know?

Astatine may be the rarest naturally-occurring element in the Earth's crust. The entire crust appears to contain about 28 grams only.



Joseph Priestley

C_2H_4

Why is it said that oxygen has a complicated history?

Oxygen is crucial for the survival of humans, animals and plants alike. The complex history of the discovery of oxygen began with it first being discovered by the Swedish chemist Carl Wilhelm Scheele in 1772. He had produced oxygen gas by heating mercuric oxide and various nitrates. As it was the only known agent to support combustion at that time, Scheele called it 'fire air.' His manuscript titled *Treatise on Air and Fire* which he sent to the publisher in 1775 contained an account of his discovery. It was published in 1777.

Meanwhile, Joseph Priestley had independently discovered oxygen as well as published his findings in 1775. As this paper, titled *An Account of Further Discoveries in Air* preceded Scheele's publication by two years, Priestley is given priority in the discovery.

Another person who also discovered oxygen around this time was Antoine Lavoisier. He was the French chemist who recognised it as an element and even coined the name 'oxygen.' The name is derived from the Greek word that means 'acid former', a property that oxygen does not really possess.

Who was the first to isolate pure methane?

In the November of 1776, the Italian physicist Alessandro Volta scientifically identified methane for the first time. Inspired by a paper written by Benjamin Franklin on 'flammable air,' Volta collected the gas rising from the marshes of Lake Maggiore that straddles Italy and Switzerland. He succeeded in isolating methane by 1778.

The name 'methane,' derived from the word 'methanol' was coined years later by the German chemist August Wilhelm von Hofmann in 1866. With the chemical formula CH_4, methane is the simplest hydrocarbon containing a single carbon atom and four hydrogen atoms. It is a greenhouse gas available in small quantities in the earth's atmosphere. A principal component of natural gas, methane is flammable and used as fuel all over the world.

Alessandro Volta

Light like Hydrogen

Hydrogen is the lightest of all elements. Hence it is placed first in the periodic table.

Why is uranium an important element?

Though uranium has been in use since ancient times to produce yellow coloured ceramic glazes, Martin Heinrich Klaproth formally discovered uranium in 1789. Klaproth's discovery came through his study of the mineral pitchblende, which was thought to be an iron or zinc ore. In his experiment, pitchblende was dissolved in nitric acid. Adding potash to this created a yellow precipitate. When more potash was added, this yellow precipitate dissolved. Since these reactions were unlike any known element, Klaproth concluded that he had discovered a new element. As the planet Uranus had recently been discovered, he named the element after it.

Martin Heinrich Klaproth

The first sample of uranium metal isolated by heating uranium tetrachloride with potassium was made in 1841 by Eugène-Melchior Péligot in Paris.

In addition to its value to chemists, uranium was only used as a glass and ceramic colouring agent during the 1800s. This changed when Henri Becquerel discovered radioactivity using uranium in 1896. All isotopes of uranium possess radioactive properties in varying degrees. Uranium came to be used as a fuel in nuclear power plants.

Who first deduced the structure of benzene?

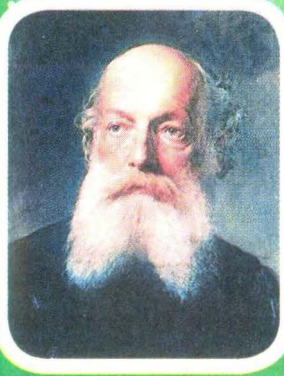
The structure of benzene that we know today was deduced from a dream! Benzene is a colourless liquid and its structure has fascinated scientists since its discovery.

Benzene was first discovered by the English scientist Michael Faraday in 1825. Archibald Scott Couper in 1858 and Joseph Loschmidt in 1861 suggested possible structures that contained multiple double bonds or multiple rings; however the chemists found it difficult to make conclusions without sufficient proof.

A widely accepted suggestion regarding the structure of benzene was made in 1865 by the German chemist Friedrich August Kekulé. He published a paper in French proposing that benzene is made up of a ring of six carbon atoms with alternating single and double bonds. It was said that this solution came to Kekulé in a dream in the form of a snake that was eating its own tail. The cyclic nature of benzene was confirmed in 1929 by crystallographer Kathleen Lonsdale.

The Oxygen Weight

Almost two-thirds of the weight of living things comes from oxygen because living things consist largely of water, and 88.9 per cent of water's weight comes from oxygen.



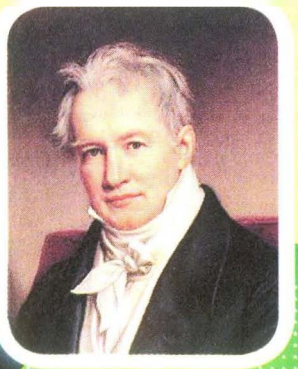
Friedrich August Kekulé

Why was discovering the composition of water a milestone in chemistry?

Water is the only compound that exists in solid, liquid and gaseous states on our planet. With its many unique properties, water is vital for our survival.

Earlier, water was believed to be an element. Its real composition was discovered by the chemist Henry Cavendish. He created an explosion by mixing hydrogen and oxygen called the oxyhydrogen effect and established that water is not an element, but a compound. Cavendish announced the composition of water to the Royal Society, London on January 15th, 1784.

The decomposition of water by electrolysis into hydrogen and oxygen was first done by English chemists William Nicholson and Anthony Carlisle in 1800. Five years later, Joseph Louis Gay-Lussac and Alexander von Humboldt showed that water is composed of two parts hydrogen and one part oxygen. The formula for water, 'H_2O' was made in 1811 by the Italian physician Amadeo Avogadro.



Alexander von Humboldt

Why is the formulation of Avogadro's law a turning point?

Avogadro's law is a fundamental law of gases proposed in 1811.

It states that equal volumes of different gases contain equal number of molecules under the same temperature and pressure. For example, one litre of Nitrogen gas and one litre of Chlorine gas contain the same number of molecules at Standard Temperature and Pressure (STP). STP is the standard condition often used for measuring gas density and volume, where air is at 0 degree Celsius and 10^5 pascals.

In the 1800s, scientists were still learning the difference between atoms and molecules. Therefore, discovering that the volume of a gas was directly proportional to the number of particles it contained, was revolutionary. It was crucial in establishing the formulas for simple molecules. Over time, it was understood that gases show small deviations from the ideal behaviour and the law holds only approximately.

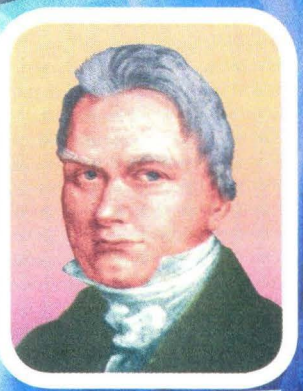
Amadeo Avogadro

What is an isomer? Who noticed isomerism first?

Some ions or molecules have identical formulas but different structures; these are called isomers. Because they have identical formulas, each isomer contains the same number of atoms though their atomic arrangement would be different. Let's take a look at glucose and fructose. Both glucose and fructose have the same chemical formula- $C_6H_{12}O_6$ but they have two distinct structures.

Friedrich Wohler was the first to notice this phenomenon. In 1827, Wohler realised while preparing silver cyanate that despite having the same elemental composition as silver fulminate, its properties were entirely different. Wohler's discovery challenged the prevailing chemical understanding.

Isomerism was accepted widely after similar discoveries were made. For example, Wohler himself discovered another pair of compounds- urea and ammonium cyanate in 1828. They too had same atomic compositions but were chemically distinct. Jons Jacob Berzelius introduced the term isomerism to describe this phenomenon.



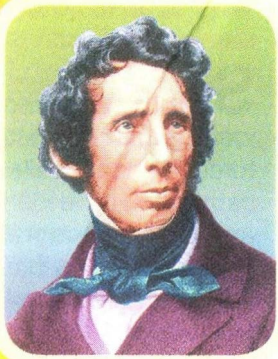
Jons Jacob Berzelius

Heavy Enough

The heaviest naturally occurring element in the universe is uranium.

Full of Water

A jellyfish and a cucumber are made up of 95 per cent water. 70 per cent of the human brain is water.



Friedrich Wohler

What is electrolysis and when was it discovered?

When a chemical reaction is started with electricity, it is called electrolysis. It is usual for reactions involving liquids, especially with ions dissolved in water.

You know what ions are. Ions are atoms or molecules containing unequal number of protons and electrons, making it charged. Electrolysis was first performed in 1785 when Martinus van Marums used an electrostatic generator to reduce tin, zinc, and antimony from their salts.

William Nicholson and Anthony Carlisle found the composition of water using electrolysis. Electrochemistry began with

Who first made urea in the lab?

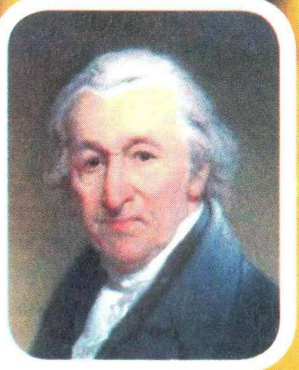
Urea or carbide was first discovered in human urine by H.M. Rouelle in the year 1773. Friedrich Wohler synthesised it in 1828 during an attempt to make ammonium cyanate, as a part of his ongoing study of cyanates. On treating silver cyanate with ammonium chloride solution, he obtained a white crystalline material which proved identical to urea obtained from urine.

Urea became the first organic compound to be synthesised from inorganic starting materials. Wohler's synthesis also marked the beginning of organic chemistry, the first in-vitro synthesis of a chemical compound otherwise produced only by living systems.

Urea is a normal component of blood and many tissues.

the electrolysis of water and helped scientists learn more about the nature of chemical compounds.

The word "electrolysis" was introduced by Michael Faraday in the 19th century. The process is commercially relevant as an electrolytic cell is used at a stage in the separation of elements from naturally occurring sources such as ores.



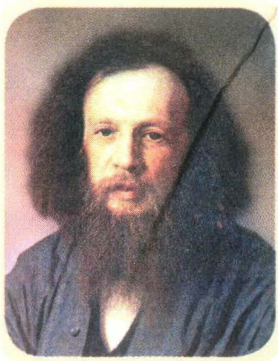
Martinus van Marums

Who is considered as the pioneer of the periodic table?

The modern periodic table lists the elements in the order of increasing atomic number, which is the number of protons in the nucleus of an atom.

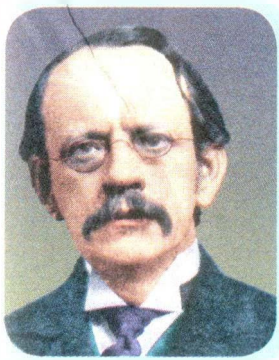
One of the initial attempts to classify the elements was done by Antoine Lavoisier in 1789. He classified them as gases, non-metals, metals and earths based on their properties. In 1829, triads of elements with chemically similar properties such as sodium, lithium and potassium were recognised by Johann Döbereiner. In the following decades many attempts were made to group elements together.

A pivotal classification came in 1866 when Russian chemist Dmitry Mendeleev listed the elements by atomic weight. He identified a pattern wherein similar elements appeared at regular intervals or periods. Mendeleev first published his periodic table in 1869 followed by a revised version in 1871. It left gaps where a break in the pattern occurred. He correctly predicted that those gaps represented undiscovered elements.



Dmitry Mendeleev

Julius Lothar Meyer was a contemporary of Mendeleev. Meyer also produced several periodic tables between 1864 and 1870. His 1868 table listed the elements in order of atomic weight, with elements with the same valency arranged in vertical lines, remarkably like Mendeleev's table. Unfortunately, Meyer's work was not published until 1870 after Mendeleev's table had been published.



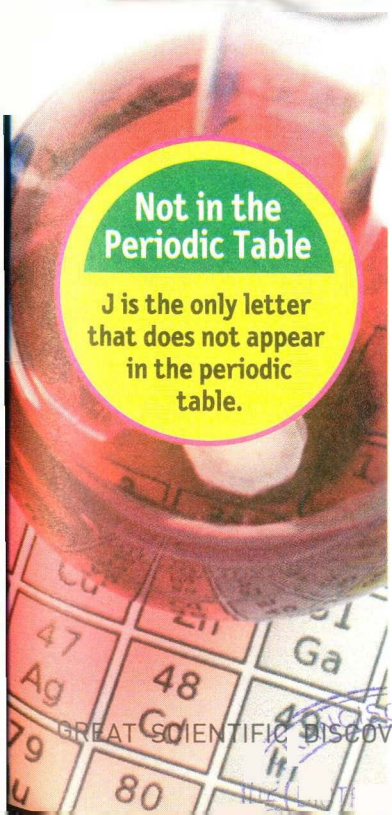
J. J. Thomson

Who discovered electrons?

An electron is a negatively charged subatomic particle represented by the symbol e–. The mass of an electron is only 1/1836 that of a proton.

Electrons were discovered by J. J. Thomson in 1897. He was studying the properties of cathode rays. Thomson constructed a glass tube from which much of the air was pumped out and then he applied a high electrical voltage between two electrodes at either end of the tube.

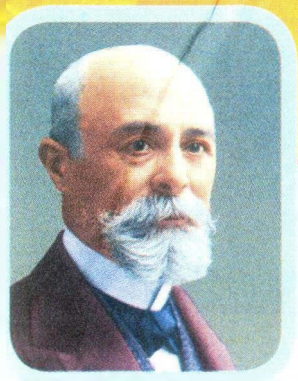
He detected that a stream of particles (ray) was coming out from the negatively charged electrode (cathode) to the positively charged electrode (anode). This ray was called cathode ray. He proved that these cathode rays could be deflected, or bent, which meant that they were made of small particles. He named these particles 'corpuscles.' Thomson initially underestimated the relevance of his discovery. He had assumed that it was too insignificant to be of importance to those outside a lab. However, the magnitude of this discovery was soon realised. The name 'electron,' advocated by G. F. Fitzgerald, J. Larmor, and H. A. Lorenz was adopted by the scientific community.



Who discovered radioactivity?

In 1896, Henri Becquerel was using naturally fluorescent minerals to study the properties of X-rays. He exposed potassium uranyl sulfate to sunlight and then placed it on photographic plates wrapped in black paper. He believed that uranium absorbed the Sun's energy and then emitted it as X-rays.

This assumption was later proved wrong. Because it was cloudy and overcast in Paris when Becquerel did his experiment, he expected it to fail because uranium needed sunlight as per his belief. However, when he developed the photographic plates anyway, Becquerel found strong and clear images! This proved that uranium emits radiation without an external energy source and thus radioactivity was discovered.



Henri Becquerel

The term radioactivity was coined by Marie Curie, who together with her husband Pierre, began investigating the phenomenon discovered by Becquerel. They extracted uranium from an ore and were surprised to find the leftover ore more radioactive than pure uranium. Their conclusion that the ore had more radioactive elements led to the discovery of polonium and radium.

Why is it said that alizarin has a long history to boast of?

Alizarin ($C_{14}H_8O_4$) is an organic compound that has been in use as red dye, particularly for textiles. It's traditionally derived from the roots of plants of the madder genus.

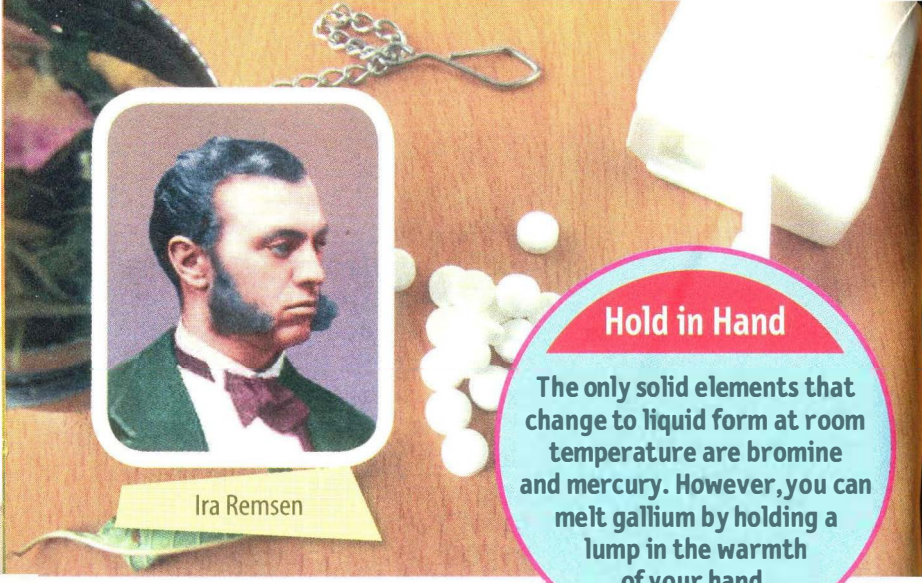
German chemists, Carl Graebe and Carl Lieberman working for the chemical company BASF found a way to synthesise alizarin in 1868. They demonstrated that the compound could be made from a chemical called anthracene, extracted from coal tar. This mode of production was cheaper as well. Simultaneously, the English dye chemist William Henry Perkin had independently discovered the same synthesis. However, the BASF group filed their patent one day before Perkin.

As one of the few red dyes available at that time, production of natural alizarin provided livelihood to thousands of people until it began to be synthetically produced. Synthetic alizarin was produced commercially at a fraction of the cost of the natural dye. The use of alizarin has decreased over the years.

The Silver Name

The name Argentina comes from an element. The country is named after the Latin word argentum, which means silver.

Carl Lieberman



Hold in Hand

The only solid elements that change to liquid form at room temperature are bromine and mercury. However, you can melt gallium by holding a lump in the warmth of your hand.

Who discovered saccharin?

Saccharin is used as a sugar-substitute in food and drinks regardless of its unpleasant aftertaste. This is mainly because it is sweeter than sugar and does not make people fat. Saccharin was first produced accidentally in 1879 by Ira Remsen and Constantin Fahlberg, two chemists working on coal tar derivatives in Ira Remsen's laboratory.

Constantin Fahlberg found an unaccountable sweet taste to his food despite thoroughly washing his hands after leaving the lab. He inspected the laboratory apparatus by taste test and finally discovered the source, which turned out to be saccharin. Fahlberg and Remsen published their findings in 1880.

Saccharin is the first commercially available artificial sweetener. Describing the method of production, Fahlberg applied for patents in different countries in 1884. Subsequently, he began producing it commercially within two years and amassed considerable wealth. This created some conflict as Ira Remsen was excluded from the patent which claimed Constantin Fahlberg to be solely responsible for the discovery.

When was silicon discovered?

Silicon is an element represented as Si. Sir Humphry Davy proposed the name "silicium" for silicon after an attempt to isolate it in 1808.

In 1811, Gay-Lussac and Louis Thénard are thought to have prepared impure amorphous silicon by heating recently isolated potassium metal with silicon tetrafluoride. They however, did not purify the product, nor did they identify it as a new element. Silicon's present name was given in 1817 by Scottish chemist Thomas Thomson.

Jöns Jacob Berzelius is credited with the discovery of silicon. In 1824, he used the method followed by Gay-Lussac to prepare amorphous silicon and then purified the product into a brown powder through repeated washing.

Silicon of lesser purity is used in metallurgy as a reducing agent and as an alloying element in steel, aluminium, brass, and bronze.

Silicon dioxide (silica) and various silicates are the most important compounds of silicon. Silica in the form of sand and clay is used to make concrete and bricks. It is also used as refractory material for high-temperature applications.

Luigi Palmieri

When did scientists confirm the presence of helium on Earth?

Helium was first discovered in the corona surrounding the Sun and later found in gases leaking from Mount Vesuvius. It is the second-most abundant element in the universe.

The first evidence of helium was observed on 18 August 1868, in the spectrum of the chromosphere of the Sun. It was discovered on Earth much later. Italian physicist Luigi Palmieri detected helium on Earth for the first time through its D_3 spectral line in 1881. He found it while analysing a material that had sublimated during a recent eruption of Mount Vesuvius. The first person to isolate helium on Earth was the Scottish chemist, Sir William Ramsay. On 26 March 1895, he heated a mineral called cleveite, which contains uranium and discovered that it gave off a gas. The gas was identified by the yellow line in its spectrum, which matched that of the helium in the Sun.

The same year, chemists Per Teodor Cleve and Abraham Langlet in Uppsala, Sweden collected enough helium to determine its atomic weight accurately. Later, Ramsay and a British chemist Frederick Soddy discovered that helium is produced whenever radioactive elements decay.

Airbag Safety

The airbags in cars contain a substance called sodium azide. In case of a collision, they trigger off a process by which the bags inflate quickly, and then deflate, providing the passengers with adequate cushioning from injuries.

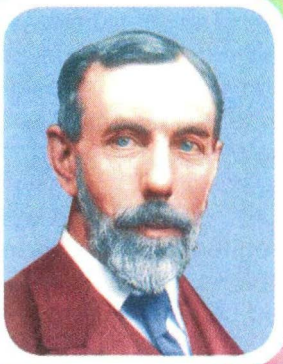
Who discovered the noble gases?

Noble gases are a group of chemical elements with similar properties. Six naturally occurring noble gases are helium, neon, argon, krypton, xenon and radioactive radon. As we saw before, helium was first discovered in 1868, while looking at the chromosphere of the Sun and was first isolated by William Ramsay.

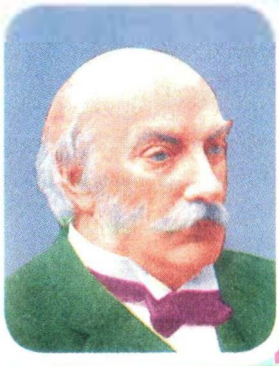
Argon, the lazy one, was discovered by Lord Rayleigh and William Ramsay at University College, London in 1894. It was named so, due to its inert character. Krypton, neon, and xenon were discovered by William Ramsay in 1898. Radon was first identified in 1898 by Friedrich Ernst Dorn. However, it was not considered a noble gas until 1904 when its characteristics were found similar to other noble gases.

In 1904, Rayleigh and Ramsay received the Nobel Prizes in Physics and in Chemistry respectively for their discovery of the noble gases.

As these gases occur in smaller amounts in the atmosphere, they are also called rare gases. Helium is found sealed within some of the radioactive minerals and can be released on heating. Others are obtained by fractional distillation of liquid air.



William Ramsay



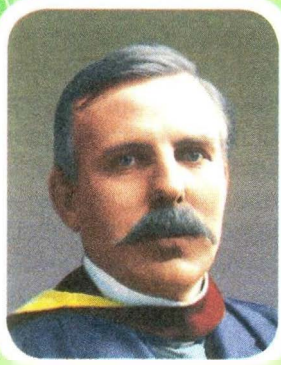
Lord Rayleigh

Who discovered the subatomic particle, proton?

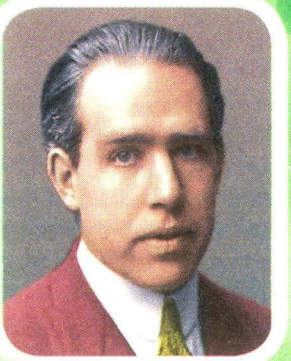
Proton is one of the constituents of an atom, besides neutron and electron. These positively charged protons reside in the nucleus of the atom and add to the overall positive charge of a molecule.

Ernest Rutherford is generally credited with the discovery of protons. He discovered alpha and beta 'rays' from uranium in 1899. The alpha rays were later found to be from the nuclei of helium atoms. In 1919 Rutherford conducted many experiments to explore radioactivity. As a result of one of these experiments, he discovered that atoms have a concentrated positive centre charge which contains most of the mass of that atom.

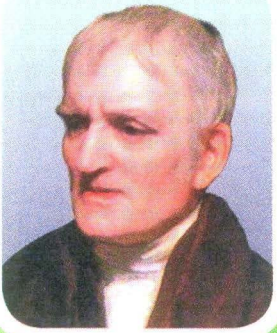
Rutherford suggested that the nucleus carried a positively charged particle. He called it proton; a name derived from the Greek word 'protos' which means 'first'. The number of protons differ from one element to another thereby giving each nucleus a different charge. This meant that the hydrogen nucleus, which has a single proton, was an elementary particle.



Ernest Rutherford



Niels Bohr



John Dalton

Who were the major contributors in finding the atomic structure?

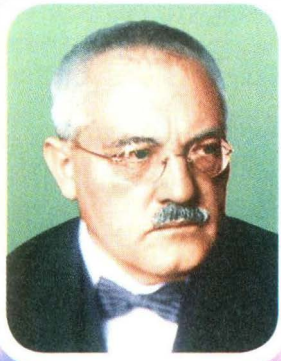
John Dalton, J.J. Thomson, Ernest Rutherford, and Niels Bohr were the scientists who made notable contributions towards the study of atomic structure.

Dalton successfully stated about atoms, but failed to identify the subatomic particles. Sir Joseph John Thomson came up with a model of an atom in the 1900s. He described atom as a positively charged sphere into which negatively charged electrons were embedded. Thomson's model can be visualised as a plum pudding with the positively charged atom and plum pieces as electrons. Thus, the idea came to be called the 'plum pudding model.'

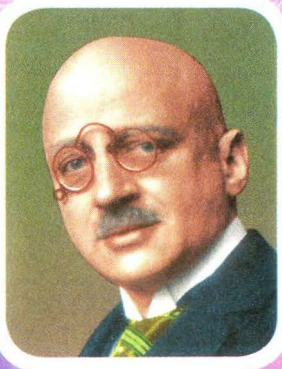
Rutherford was J.J. Thomson's student. He modified his teacher's model when another subatomic particle called nucleus was discovered.

Neils Bohr put forth his model of the atom in 1915. One of the most significant ideas he suggested was that electrons were placed on distinct 'stationary orbits' inside the atom.

What did Fritz Haber and Carl Bosch discover?



Carl Bosch



Fritz Haber

Nitrogen is an essential nutrient for plants. Though four-fifths of air is made up of nitrogen, plants are unable to absorb it directly. To resolve this, plants were given nitrogen-rich fertilisers. By the 1900s however, natural supplies of nitrogen such as bird droppings were in short supply.

In 1909, German chemist Fritz Haber successfully managed to capture atmospheric nitrogen. Nitrogen was combined with hydrogen under high pressure and heat, to form ammonia which could be made into fertilisers and similar products. This process, known as the Haber process, had potential applications in industrial and agricultural sectors.

In 1913, a research team from BASF, under the leadership of Carl Bosch developed the first industrial level application of this process, now occasionally called the Haber-Bosch process.

In the early twenty-first century, the global demand for ammonia was over 100 million tons. The success of the Haber process lies in satisfying about 99 per cent of this demand.

What is an isotope?

An isotope is any form of a chemical element that has the same number of protons in the nucleus, or the same atomic number but has a different number of neutrons in the nucleus.

For example, three isotopes of carbon are found in nature- carbon-12, carbon-13 and carbon-14. All three have six protons, but their neutron numbers differ, being 6,7, and 8 respectively. Isotopes may be stable or unstable. If unstable, they will be radioactive. The term isotope is a combination of the Greek word 'isos', meaning equal, and 'typos' which means place.

Radiochemist Frederick Soddy was the first to suggest the existence of isotopes in 1913. He made this inference based on studies of radioactive decay chains. Soddy was also the first to isolate isotopes by degenerating uranium.

The first evidence for multiple isotopes of a stable, non-radioactive element was found by J. J. Thomson in 1913. The effects of isotopes on atomic mass was discovered by Harold Urey and G. M. Murphy in 1931.

Frederick Soddy

Einstein's Friend

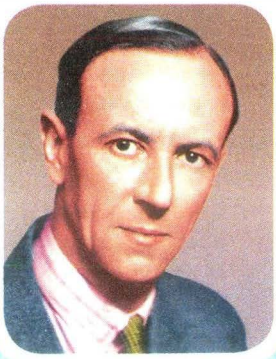
Niels Bohr and Albert Einstein were good friends who however had different takes on the positioning of electrons.

Who discovered neutrons?

In 1932, James Chadwick became the first person to discover neutrons. Chadwick had experience working with Rutherford, who discovered protons.

After the discovery of protons, scientists found that protons were not the only particle in the nucleus. The number of protons in the nucleus is called the atomic number. It is equal to the positive charge of the atom. During atomic disintegration, scientists were baffled to find that atomic number was less than atomic mass. For example, a helium atom's mass is four whereas its atomic number is just two.

Because electrons have almost no mass, scientists assumed that something other than protons were adding to the mass. Chadwick kept this problem in mind even while he was engaged in other matters. He conducted many experiments to find a neutral particle with zero charge that has the same mass as a proton. Finally, Chadwick proved the existence of neutrons and determined that its mass was about 0.1 per cent more than the proton's. In a characteristic display of modesty, he published his findings in a paper titled *Possible Existence of a Neutron*. Chadwick was awarded the Nobel Prize in 1935 for his discovery.



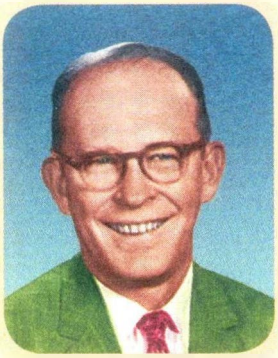
James Chadwick

What is radiocarbon dating and who proposed it?

How do we know that dinosaurs lived on Earth millions of years ago? From their fossils of course. But how do we know their age? One way to do it is through radiocarbon dating.

The ages of objects can be determined by finding out the amount of radiocarbon in it. All living things contain traces of carbon-14, a radioactive element of carbon. Dating an object with the help of radiocarbon is known as 'radiocarbon dating' and it can date objects upto 50,000 years old. Willard Libby first proposed this innovative method for dating organic material in 1946 which is done by determining the half-life of radioactive carbon.

Carbon-14 is formed when cosmic rays hit the atmosphere and react with atmospheric nitrogen. Carbon -14 is taken in by plants which in turn enters all living organisms through the food chain. When an animal or a plant dies, carbon-14 atoms decay at a steady rate. The amount of carbon-14 in a dead plant or animal can give us information regarding when it died. The process lies in finding the amount of carbon-14 and dating it using half-life of the element. Half-life is defined as the period of time after which half of a given sample will have decayed. The half-life of carbon-14 is about 5,500 years. This means that after 5,500 years after the death of a plant or an animal, half the carbon-14 atoms at the time of its death won't be present. Therefore, the lesser the amount of carbon-14, the older the sample.



Willard Libby

What is fullerene? When was it discovered?

Fullerene or buckminsterfullerene is a series of hollow carbon molecules that form either a closed cage or a cylinder. Fullerenes in the form of a closed cage are sometimes called buckyballs whereas cylindrical fullerenes are called carbon nanotubes.

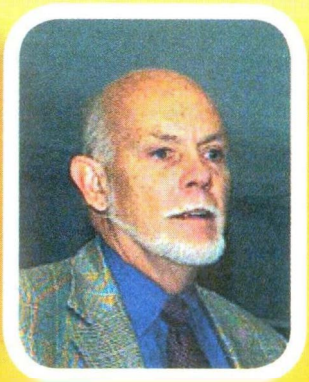
The first fullerene was discovered in 1985 by the British chemist Sir Harold W. Kroto, Richard E. Smalley and Robert F. Curl, Jr., of the United States. The trio were awarded the Nobel Prize in 1996 for their discovery.

It is in turn named after the American architect R. Buckminster Fuller, whose geodesic dome is constructed on the same structural principles. Sumio Lijima of Japan identified the elongated cousins of buckyballs called carbon nanotubes in 1991.

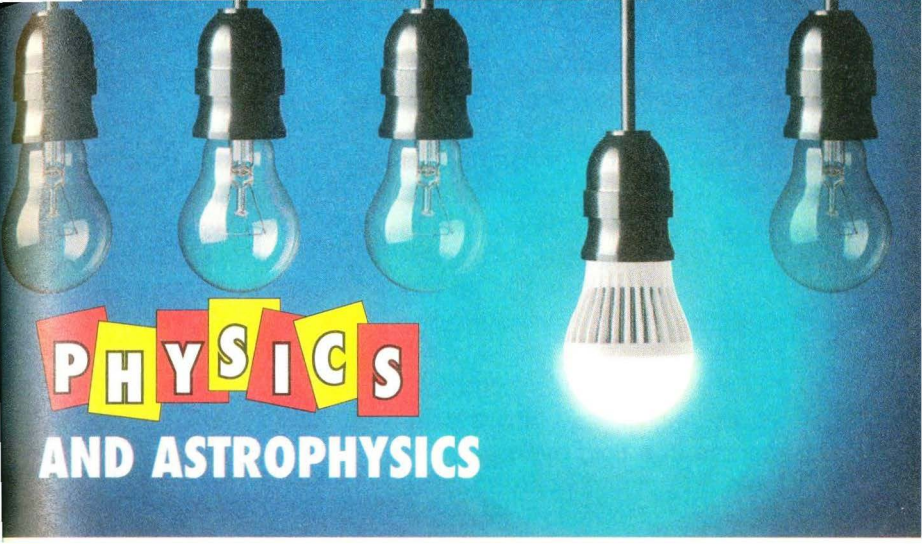
Though fullerenes had been predicted for some time, they were detected in nature and outer space only after their accidental synthesis in 1985. Until then, graphite, diamond, and amorphous carbon such as soot and charcoal were the only allotropes of carbon. The discovery of fullerenes has led to a new understanding of sheet materials and created new vistas in nanoscience and nanotechnology.

Atomic Nucleus

The atomic nucleus is a small, dense region at the centre of an atom consisting of protons and neutrons. It was discovered by Ernest Rutherford in 1911.



Richard E. Smalley



Why is it said that the knowledge of electricity existed in ancient times?

People were aware of shocks from eels long before they knew about electricity. Egyptian texts dating back to 2750 BC referred to these fish as the "Thunderer of the Nile".

Ancient cultures around the Mediterranean knew that certain objects such as rods of amber, when rubbed against cat's fur could attract light objects like feathers.

Electricity was nothing more than an intellectual curiosity until the 1600s, when the English scientist William Gilbert wrote *De Magnete* on his study of electricity and magnetism. However, Benjamin Franklin is often the one credited for the discovery of electricity. Franklin came up with the concept of electricity consisting of positive and negative elements. Franklin's idea formed the basis of many future inventions.

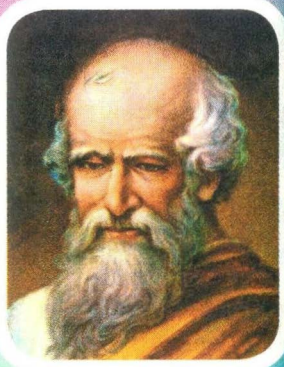
Franklin's famous kite experiment was conducted to prove his assumption that lightning was a form of electricity. He flew a kite with a metal key attached to the string during a thunderstorm. As he expected, the key conducted electricity from the storm clouds, which was transferred to the kite and gave him a shock.

What is Archimedes principle?

Why do some things float in water while the others sink? The answer to this question was found by the Greek scientist Archimedes. The principle he formulated is called the Archimedes principle.

The Archimedes principle states that, when anything is immersed in a fluid even partly, it feels an upward push equal to the weight of the fluid it displaces. For instance, a ship launched into the ocean will sink until it displaces water equal to its own weight.

There is an anecdote related to this discovery. King Hiero II of Syracuse wished to give a gold crown to a temple. The king himself supplied the gold. However, he had a suspicion that the goldsmith mixed some silver to it. The king asked Archimedes to find the truth without damaging the crown. While taking a bath, Archimedes noticed that the level of the water in the tub rose as he got in. He realised that the submerged crown would displace an amount of water equal to its volume. Thus, the Archimedes principle was formulated.



Archimedes

Eureka!

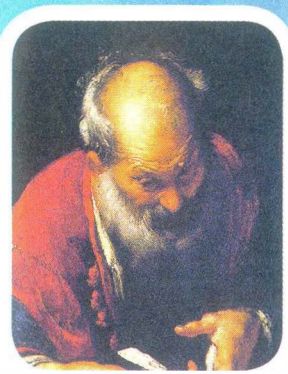
It is said that Archimedes leaped out of his bath and ran naked through the streets, shouting 'Eureka', which means 'I have found it'.

Who was the first to measure Earth's circumference?

Earth's circumference was first accurately measured more than 2,000 years ago by the Greek astronomer Eratosthenes.

Eratosthenes heard that midday sunlight shines straight down to the bottom of deep wells, on the same day each year in the nearby town of Syene. This indicated that the Sun was directly overhead in Syene on that day. However, on the same day, sunlight fell only on the sides of the wells in Alexandria.

Eratosthenes reasoned that the difference in the angle of incoming sunlight was due to the curved surface of Earth. By measuring this angle, he related the distance between Alexandria and Syene to the total dimension of the globe.

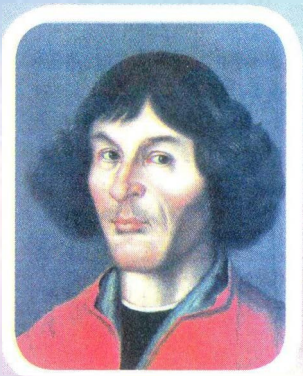


Eratosthenes

On the day the Sun shone at the bottom of the wells in Syene, Eratosthenes measured the sun's position in the sky over Alexandria.

It was seven degrees away from the zenith, which meant that Syene was seven degrees away from Alexandria. He then made several calculations considering this angle and the distance between Alexandria and Syene, which is about 800 kilometres.

There is only a difference of five per cent between the answer he got (42,000 km) back then and the value accepted today (40,075 km).



Nicolaus Copernicus

Father of Geography

Eratosthenes gave shape to the discipline of geography, including most of the terms used even today.

What is heliocentrism and who proposed it?

For almost 2000 years, Western thinking was influenced by the concept of universe being centred around Earth, advocated by Aristotle and Ptolemy. In the 16th century, the Polish astronomer Nicolaus Copernicus proposed a new concept.

In his book *On the Revolutions of the Heavenly Bodies*, Copernicus proposed that it was the Sun at the centre of the solar system and not Earth. This model was called the heliocentric system in 1543.

The Copernican model displaced Ptolemy's geocentric model. Copernican heliocentrism became the launching point for modern astronomy. It described Earth as just another planet, placed third outward from the Sun.

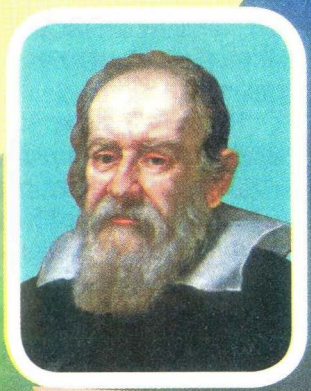
Copernicus also explained that stars are distant objects that do not revolve around the Sun. Instead, Earth rotates once in 24 hours. This causes the stars to appear as if they revolve around Earth in the opposite direction.

How many moons does Jupiter have?

Jupiter has 79 known moons, almost making it a solar system by itself. In January 1610, Italian astronomer Galileo Galilei discovered four of Jupiter's moons which are now called Io, Europa, Ganymede and Callisto. Originally, Galileo referred to them numerically as I, II, III, and IV. The first moon he discovered was Io and it is closest to Jupiter among the four. He published his observations in a book called *The Starry Messenger*. However, Simon Marius, who discovered the moons independently around the same time as Galileo, gave these moons their present names.

Galileo's discovery proved the importance of the telescope as a tool for astronomers. It made possible for humans to perceive celestial objects that remained unseen by the naked eye.

Galileo's discovery was a turning point in astronomical history as it put an end to the geo-centric model of the universe.

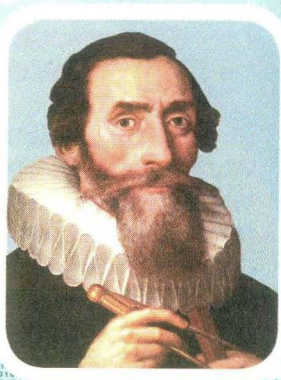


Galileo Galilei

Who proposed the laws of planetary motion?

In the early 17th century, the concept of planetary motion was based on the ideas of Copernicus. People believed that planets orbited the Sun at a constant speed in perfect circles. This belief was challenged by the astronomer Johannes Kepler. He used the data meticulously gathered by his former employer Tyco Brahe, who had worked, without even the advantage of a telescope. Kepler calculated that rather than circles, the planets' paths were ovals or ellipses and they did not have a constant speed. His discoveries certainly made people aware that the universe was not as simple as initially thought.

Kepler's first two laws on planetary motion were published in 1609 and the third one in 1619. The application of Kepler's laws extends to the motions of natural and artificial satellites and unpowered spacecrafts in orbits in stellar systems or near planets. It is to be noted that these laws, as formulated by Kepler, do not take gravitational interactions between planets into consideration.



Johannes Kepler

Who discovered the diffraction effects of light?

It is believed that light travels in straight lines. However, light bends very slightly at the edges of objects. Thus, the shadows formed will be a little smaller than if it were a simple straight line. This effect is called diffraction.

The effects of diffraction of light were first carefully observed and characterised by Francesco Maria Grimaldi. Grimaldi also coined the word 'diffraction' from the Latin word *diffringere*, meaning, 'to break into pieces', referring to light breaking up in different directions. Grimaldi's observations were posthumously published in 1665. A more conclusive study was done by Augustin-Jean Fresnel who made his calculations on diffraction public in 1815 and 1818.

The discovery of diffraction supported the wave theory proposed by Christiaan Huygens. According to the wave theory, light is a stream of waves, with each wave made up of smaller wavelets. When light hits a glass at an angle, the wavelets that reached first would slow down. This causes light to bend. As the wave theory conflicted with Newton's ideas, it was not accepted until the 19th century.

The Sound Story

Sound travels at a speed of around 1,230 kilometres per hour.

Augustin-Jean Fresnel

Strange but True!

Uranus is the only planet in our solar system that rolls on its side like a barrel, while Venus is the only planet that spins in the opposite direction to Earth.

Ole Romer

Who first determined the speed of light?

As light is tremendously fast, measuring its speed was almost an impossible task. It was easier to calculate when light had travelled a long way.

Ole Romer, a Danish astronomer accidentally found this in 1676. He noticed that the time between eclipses of Jupiter's moons when they are hidden behind the planet varied throughout the year. Romer realised that it was because of variation in two things: the distance from Earth to Jupiter throughout the year and the distance travelled by light from the moons. His initial calculations estimated the speed of light to be about 220,000 km per second. Though this was 25 per cent slower than the correct speed, it was a significant start in the right direction. Christiaan Huygens later deduced that the speed of light is approximately 212,000 km/s.

In 1809, astronomer Jean Baptiste Joseph Delambre estimated the time taken by light to travel from the Sun to Earth as 8 minutes and 12 seconds. This is quite close to the modern value, which is 8 minutes and 19 seconds, at a speed of 299,792.458 metres per second.

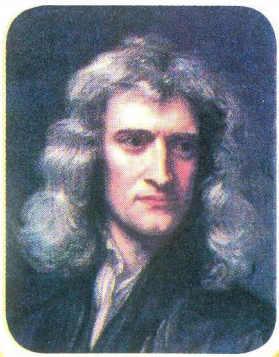
What is gravity? Who discovered it?

Gravity or gravitation, is a natural phenomenon by which all things with mass or energy—including planets, stars, galaxies, and even light are brought towards one another. Isaac Newton was the first to discover gravity.

It is said that Newton came up with the concept of gravity when he saw an apple fall, just as he was thinking about the forces of nature. Whether this particular incident happened or not, Newton realised that some force must be acting on falling objects like apples, or else, they would not start moving from the rest. He also realised that the moon would move away from the earth in a straight-line tangent to its orbit, if some force was not pulling it towards our planet. Newton called this force "gravity" and determined that gravitational forces exist between all objects.

The new discovery cleared many of the long-standing doubts such as the reason why orbiting objects do not fly off into space.

However, Newton's theory could only describe how objects attracted each other and not why they did. The answer to this was suitably explained by Einstein's Theory of Relativity.



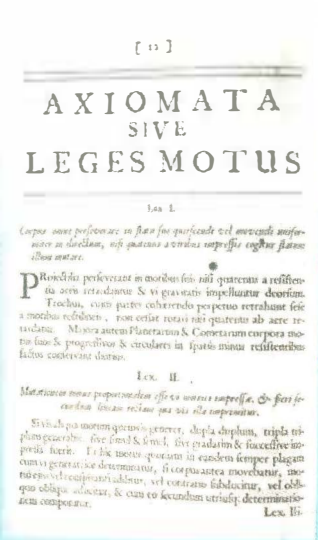
Isaac Newton

Which discovery laid the foundation for classical mechanics?

The three laws of motion formulated by Isaac Newton, laid the foundation of classical mechanics. Newton published these in his *Philosophae Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy) in the year 1687. The laws of motion are still used to get people to the Moon.

Newton's first law takes hints from Galileo's observations. Newton redefined Galileo's observation that an object in motion will continue moving in the absence of a force. As Newton's first law is a restatement of the law of inertia which Galileo had already described, Newton appropriately gave credit to Galileo.

Newton's first law states that the velocity (speed and direction) of an object only changes if a force acts on it. The second law states to what extent the object's velocity will be changed by a given force. The third law states that when a body exerts some force on another one, the second will apply an equal force in the opposite direction, that is, every action has an equal and opposite reaction.



[13]

AXIOMATA
SIVE
LEGES MOTUS

Lex I.

Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum illum mutare.

Projectilia perseverant in motibus suis nisi quatenus a resistentia aeris retardantur & vi gravitatis impelluntur deorsum. Trochus, cujus partes cohærendo perpetuo retrahunt sese a motibus rectilineis, non cessat rotare nisi quatenus ab aere retardatur. Majora autem Planetarum & Cometarum corpora motus suos & progressivos & circulares in spatiis minus resistentibus factos conservant diutius.

Lex. II.

Mutationem motus proportionalem esse vi motrici impressæ, & fieri secundum lineam rectam qua vis illa imprimitur.

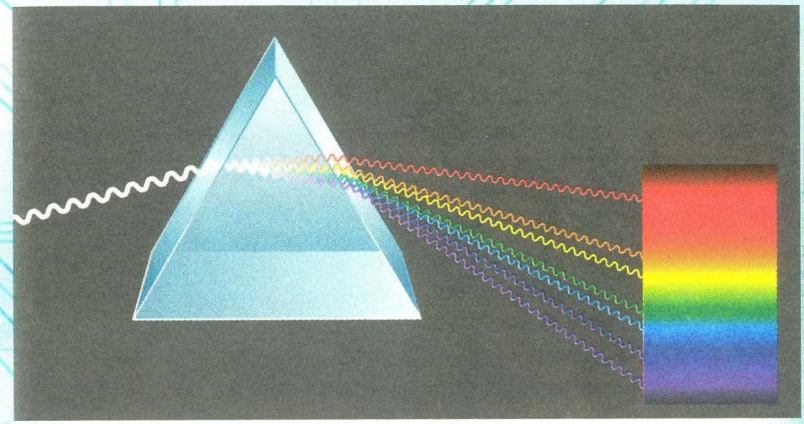
Si vis aliqua motum quemvis generet, dupla duplum, tripla triplum generabit, sive simul & semel, sive gradatim & successive impressa fuerit. Et hic motus (quoniam in eandem semper plagam cum vi generatrice determinatur) si corpus antea movebatur, motui ejus vel conspiranti additur, vel contrario subducitur, vel obliquo obliquæ adjicitur, & cum eo secundum utriusque determinationem componitur.

Lex. III.

Newton's First and Second Laws in Latin

Too Old

It's interesting to know that the literal meaning of the word 'physics' is taken from the Greek word 'knowledge of nature'. It is one of the oldest fields of science, dating back to 650 BC.

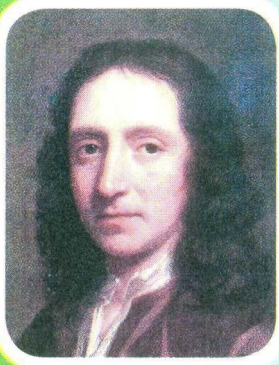


When was the composition of white light discovered?

Sir Isaac Newton discovered that white light can be broken down into its composite colours. Prior to this, most scientists believed that light was fundamentally white in colour.

When Newton started his experiments with light in the 1660s, our knowledge of light was saddled with many misconceptions. People thought that colour was a mixture of light and darkness, and that prisms coloured light. Even scientists like Robert Hooke were proponents of this theory. Realising the inconsistencies in the existing ideas about light, Newton set up a prism near his window, and projected a beautiful spectrum consisting of the rainbow of colours in visible light, 22 feet onto the far wall. To prove that the prism was not colouring the light, he recombined the light back together.

Newton's demonstration of the composition of light was a novel experience to the scientific world. Though he announced his discovery in 1670, the world took notice of it only in 1704 after he published his findings in his book *Opticks*. His discovery laid the foundation of modern physical optics.



Edmond Halley

Who predicted the periodicity of Halley's comet?

English astronomer Edmond Halley was the first person to predict the periodicity of Halley's comet. Subsequently, the comet was named after him.

Comets were believed to make a single appearance. However, Halley showed that they could orbit the Sun and make periodic appearances. Though Halley was the first to prove the periodicity of comets, he was not the first to record their appearance. The return of Halley's comet to the in-

When were infrared and ultraviolet rays discovered?

Infrared radiation was discovered in 1800 by astronomer Sir William Herschel. When visible light passes through a prism, a rainbow of colours is seen. This is called a spectrum.

Herschel discovered an invisible radiation in the spectrum that was lower in energy than the red light, through its effect on the thermometer. This was the first time that a form of light beyond visible light had been detected.

Infrared radiation has a longer wavelength than visible light. It has applications in industrial, scientific, military, law enforcement, and medical fields. For instance, night-vision devices using active near-infrared illumination allow people or animals to be observed without the observer being detected.

ner solar system had been observed and recorded at least since 240 BC by astronomers. Chinese and European chroniclers had also made records of Halley's comet, although they did not realise that these were reappearances of the same object.

Periodic reappearances of Halley's comet have been scientifically investigated even in the modern era. The three appearances from 1531 to 1682 were noted by Halley who recognised it as the same comet. In 1705, he predicted that it would return in 1758. Halley's prediction came true and the comet was named in his honour. Unfortunately, Halley did not live long enough to see its return. He passed away in 1742.

Star with Hair?

The name comet comes from the Greek word meaning 'hair of the head.' It came from the Greek philosopher Aristotle who observed comets as 'stars with hair'.

Ultraviolet (UV) radiation was discovered in the year 1801 by the German physicist Johann Ritter. He observed invisible rays just beyond the violet end of the visible spectrum which darkened silver chloride-soaked paper more quickly than violet light itself. Initially named oxidising rays by Ritter, these later came to be known as ultraviolet light. The word 'ultra' means 'beyond.'

Through their discoveries Ritter and Herschel proved that there are invisible forms of light beyond both ends of the visible spectrum.

William Herschel

Moon of Asteroid!

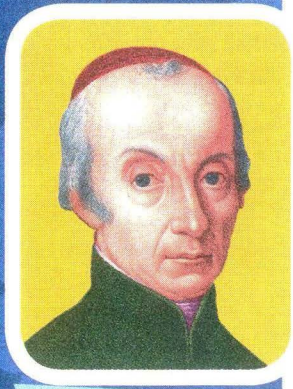
NASA's Galileo is the first spacecraft to take close-up images of asteroids in 1991. It also discovered the first moon to orbit an asteroid in 1994.

What are asteroids? Who first observed them?

Asteroids are rocky worlds revolving around the sun which are too small to be called planets. They are also known as planetoids or minor planets.

There are millions of asteroids of different sizes. When it comes to size, they may be a few feet wide or hundreds of miles long. Altogether, the combined mass of all asteroids is lesser than Earth's moon.

Giuseppe Piazzi, director of the observatory of Palermo in Sicily discovered Ceres, the first asteroid. It was mistaken as a new planet and Piazzi named it after the Roman goddess of agriculture, Ceres. Following this, more and more small bodies were discovered.



Giuseppe Piazzi

Due to the limitations of the equipment of the time, they appeared only as points of light, like stars. This inspired the astronomer Sir William Herschel to propose the term asteroid, meaning star-like or star shaped.

Hundreds of asteroids have been discovered till date and more are added every year. Millions more await discovery but may be too small to be seen from the earth.

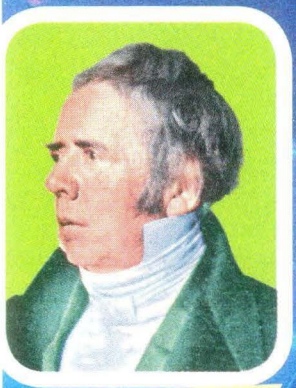
What was the greatest contribution of Hans Christian Orsted?

The greatest contribution made by Hans Christian Orsted is the discovery of electromagnetism. Some early scientists such as William Gilbert and Benjamin Franklin suspected a connection between electricity and magnetism. But, until the 1820s, electricity and magnetism were treated as separate entities.

William Gilbert experimented with electricity in the early 17th century hoping to improve maritime navigation using magnetic compasses. Many of Benjamin Franklin's experiments were aimed at a better understanding of the relationship between electricity and magnetism.

Ultimately, it was Orsted who discovered the connection. He put a compass needle near a wire, then connected the wire to the terminals of a battery. The needle set itself at right angles to the wire, demonstrating that electricity could create magnetism.

However, Orsted did not come up with a suitable explanation for the phenomenon immediately after the experiment. He engaged in intensive investigations for three months and then published his findings. Orsted proved that an electric current produces a magnetic field as it flows through a wire.

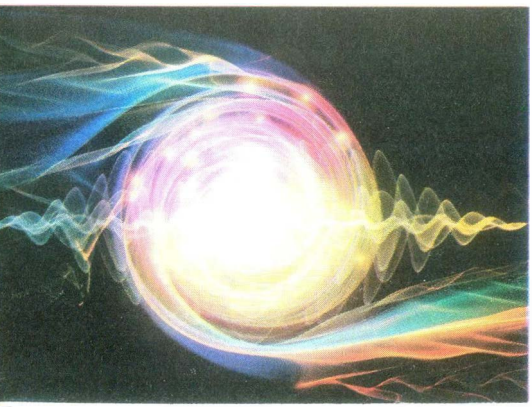


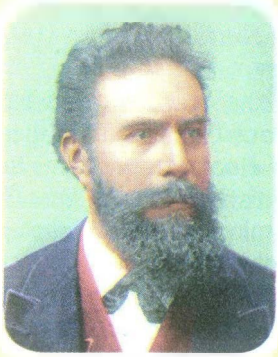
Hans Christian Orsted

Why is the discovery of photon important?

Light has the unique characteristics of behaving both like a particle and a wave at the same time. We discussed the wave theory of light earlier. However, light also has particle nature. Light is made of particles called photons. In physics, a photon is a bundle of electromagnetic energy. It is also referred to as a quantum of electromagnetic energy. Photons are zero mass particles without charge, which means they are electrically neutral.

The concept of light as discrete particles had been around for centuries. It was formalised in Newton's construction of the science of optics. Yet, the 1880s saw an increased interest in the wave nature of light which had become evident, and scientists more or less ignored the particle theory. Even the term 'photon' was only coined in 1926 by Gilbert N. Lewis. Particle theory returned to the forefront of scientific discussions with Einstein's experiments.





Wilhelm Roentgen

Who discovered X-ray?

Electromagnetic radiations called X-rays were discovered by Wilhelm Roentgen in 1895 while investigating cathode rays. Cathode rays are electrical discharges inside a tube containing very little air.

Roentgen observed certain crystals lying near the tube that glowed while the tube was working. This was puzzling because the tube was shielded to

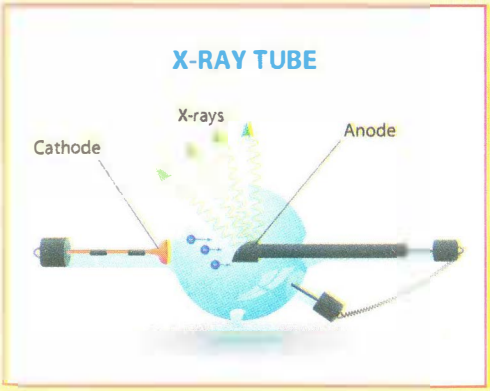
prevent light from escaping it.

Roentgen deduced that cathode rays hitting the glass of the tube were producing some other rays which made the crystals glow. Further experiments showed that these rays could also pass through solid objects and affect photographic plates. Roentgen used this property to make the first X-ray picture. He was initially reluctant to reveal his discovery to the public, afraid that other scientists may not believe him. Proving his worries baseless, the public wholeheartedly accepted X-rays.

Roentgen discovered their medical use while making a picture of his wife's hand on a photographic plate using X-rays. The photograph of his wife's hand was the first photograph of a human body part using X-rays!

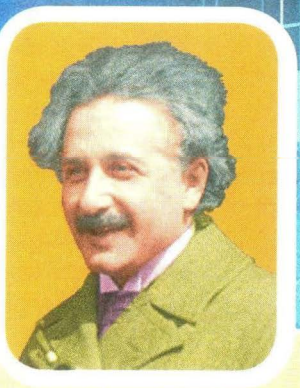
A Nightmare!

Roentgen's wife was not quite impressed by her husband's invention. After seeing the image of her hand, she said, " I have seen my death".



Einstein, the Musician

In addition to being a scientific genius, Albert Einstein was a great musician. His mother wasa gifted pianist who nurtured his love for music.



Albert Einstein

What is the theory of relativity?

The theory of relativity includes two interrelated theories by Albert Einstein: Special Theory of Relativity and General Theory of Relativity.

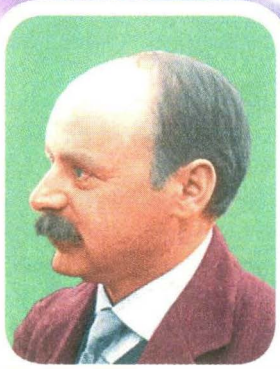
Simply put, the Special Theory says that the mass of an object depends on its speed. If a force acts on an object, it accelerates. But as it speeds up, more energy goes into increasing its mass and less into increasing its speed.

This prevents it from reaching the speed of light. One consequence is the equation $E = mc^2$, which says that mass and energy are interchangeable.

Though revolutionary, the Special Theory of Relativity was incomplete by itself as gravity was not accounted for.

Einstein remedied this in 1915 with his General Theory of Relativity. He replaced Newton's space and time with a unified space-time. According to this, gravity was a property of space, not a force between bodies. The final form of general relativity was published in 1916.

Einstein's theory revolutionised theoretical physics and astronomy.



Karl Schwarzschild

What are black holes? What was the first object considered to be a black hole?

A black hole is a great amount of matter packed into a very small area. For example, the image of a star, ten times the size of the sun squeezed into a sphere aptly describes it. The result is a gravitational field so strong that, even light can't escape. Most black holes are formed of the remnants of a large star that dies in a supernova explosion.

The idea of an object in space, dense enough to prevent even light from escaping is centuries old. Einstein first predicted black holes in 1915 with his General Theory of Relativity. Karl Schwarzschild used Einstein's General Theory of Relativity to find out what happens near a massive star that has collapsed to a single point. He found that they emit no light, but can be detected by the effect of their gravity on nearby stars.

Astronomer John Wheeler coined the term black hole in 1967. Cygnus X-1, the first object considered to be a black hole was discovered in 1964.

Who discovered superconductors?

Superconductors are materials that conduct electricity without resistance. As a result, they can conduct electricity indefinitely without losing energy unlike common conductors like copper and steel.

In 1911, Dutch physicist Heike Kamerlingh Onnes of Leiden University first observed superconductivity in mercury. When he cooled it to the temperature of liquid helium, which is 4 degrees Kelvin its resistance suddenly disappeared. The Kelvin scale represents an absolute scale of temperature.

Heike Onnes also discovered that a superconducting material can be returned to normal, non-superconducting state, in two ways. This can be done either by passing a sufficiently large current through it or by applying a sufficiently strong magnetic field. In 1913, Onnes was awarded the Nobel Prize in physics for his research in this area.

The discovery of superconductors has made drastic improvements in the medical field. With the advent of MRI machines, exploratory surgeries are no longer as necessary as it once was.

Heike Kamerlingh Onnes

Friendly Debate

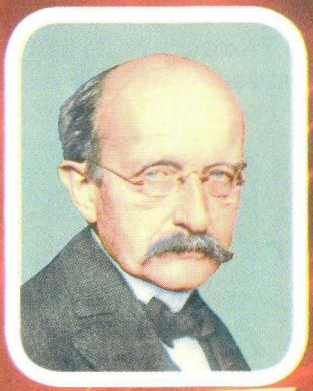
Cygnus X-1, a galactic X-Ray source, was the subject of a friendly wager between Stephen Hawking and a fellow physicist Kip Thorne in 1974. Hawking bet that the source was not a black hole. He finally conceded defeat in 1990.

Why is it said that the quantum theory changed physics forever?

One of the troubles encountered by physicists in the 1900s was that the colour of light from red-hot objects differed from their expectations. Max Planck, a German physicist, found a way to predict the colour accurately. He assumed that energy radiated only as multiples of a fixed amount called quantum. This also clarified why the energy of electrons ejected from metals by light depended on the colour of the light rather than brightness.

In the next three decades, Erwin Schrodinger, Werner Heisenberg and others utilised the quantum theory to develop a new world view in which matter and energy could be both waves and particles.

These developments transformed physics. The theoretical basis of modern physics is built on two theories: the theory of relativity and quantum theory. The first one is relevant when high speeds are involved and quantum theory is required when quantities on the scale of atoms, molecules, etc are involved.



Max Planck

When were cosmic rays discovered?

Cosmic rays were discovered in 1912 by Victor Hess. These are fragments of atoms that reach Earth from beyond the solar system. They travel nearly at the speed of light and are said to cause electronic problems in satellites and other machinery.

Though a century has passed since their discovery, cosmic rays still remain an enigma. We are still unsure about the source of cosmic rays. Most scientists associate their origins to supernovas (explosions of stars). However, they appear uniform when you look across the entire sky through observatories.

The year 2017 saw major advancements in cosmic ray science. Pierre Auger Observatory which is spread over 3,000

Victor Hess

Nature's Magic

Do you know why we float in the Dead Sea? Physics can give us the answer for this and more! Water in the Dead Sea is extremely dense due to high salt content. As a result, you can float on the surface and enjoy the sea without learning to swim.

square kilometres in western Argentina studied the arrival trajectories of 30,000 cosmic particles. Depending on where they looked, the observatory found differences in the frequency at which these cosmic rays arrived.

The exact origins of cosmic rays are still hazy, but scientists agree that the first step is knowing where they ought to look.

Werner Heisenberg

When was the Uncertainty Principle first proposed?

According to the definition in quantum mechanics, a particle is not just a particle, but also a wave. As a result, it is impossible to know the momentum, which is a product of the mass and velocity, and position of a particle, simultaneously. This is because momentum comes from a wave that is spread out while position comes from a concentrated wave. And these two do not come together.

This was proposed by the German physicist Werner Heisenberg as the 'Uncertainty Principle' in 1927. It is to be noted that the Uncertainty Principle is not apparent on the macroscopic scale of day-to-day life. Scientists usually devise easily understood physical situations as examples to demonstrate the application of the Uncertainty Principle.

Edwin Hubble

Significant Enough!

Can you believe that everything we see makes just 5 per cent of the whole universe? The rest is simply dark energy and dark matter. This certainly makes us all feel insignificant!

What makes Edwin Hubble a notable figure?

In 1929, American astronomer Edwin Hubble published one of the astounding discoveries of the twentieth century. Through observations of far off galaxies, Hubble found that the universe is expanding and the galaxies are moving away from each other. Their speeds kept increasing, the farther they were from each other. This theory is known as Hubble's Law.

Hubble's Law is regarded as the first observational foundation for the expansion of the universe. However, the idea of universe expanding at a calculable rate was not introduced by Hubble. Alexander Friedmann derived this from general relativity equations in 1922 which was published as the 'Friedmann equations.' After Hubble's discovery, Einstein called his own assumptions about a static universe his 'biggest mistake.'

Why was the formulation of the Big Bang Theory a turning point?

The widely accepted theory about the origin of our universe centres on the event now referred to as the 'Big Bang.' The basis of this theory is the observation that galaxies are moving away at great speed from one another. It was as if they were forced into movement by an ancient explosive force.

Georges Lemaitre, a Belgian priest first came up with the Big Bang Theory in the 1920s. He suggested that a single primordial atom exploded to create the universe. Hubble's observations substantiated Lemaître's theory. In addition to this, cosmic microwave radiations discovered by Arno Penzias and Robert Wilson in the 1960s were seen as reverberations of the Big Bang.

Russian physicist George Gamow revived Lemaitre's ideas in 1948 in order to explain the formation of chemical elements. British astronomer Fred Hoyle is credited for coining the expression 'Big Bang,' but he had actually used the term critically to reject this theory. Today, however, the Big Bang is the accepted explanation for the beginning of time.

When was the term 'supernova' first used?

Imagine you see a brilliant star that came into view all of a sudden in the sky at night. Though it was not there a few hours ago, it is now burning brightly. That brilliant point in the sky is a star exploding at the end of its life. Such an explosion is called a supernova (plural: supernovas or supernovae). NASA calls it 'the largest explosion that takes place in space.'

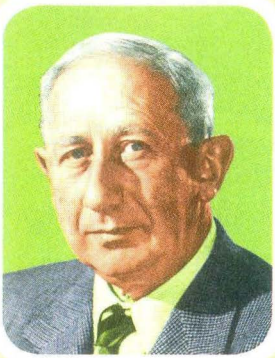
Supernovae can shine brighter than an entire galaxy and generate more energy than what the Sun can make in its entire existence. The primary source of heavy elements in the universe are supernovae. Ancient civilisations have recorded supernovas long before the invention of telescopes. RCW 86 is the oldest recorded supernova. It was seen by Chinese astronomers in 185 AD. The most famous among known supernovae is Crab Nebula.

The term 'supernova' came into use only in the 1930s. Walter Baade and Fritz Zwicky of Mount Wilson Observatory first used it in relation to an explosive event they observed, called S Andromedae or SN 1885A.

Who postulated the idea of neutrino?

Wolfgang Pauli proposed the existence of a neutral, light-weight particle present in the nucleus of an atom. This suggestion helped safeguard the fundamental law of the conservation of energy by explaining the apparent loss of energy during decay of certain atomic nuclei.

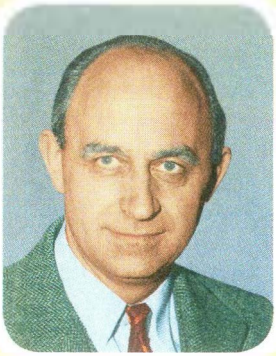
Scientists elaborated Pauli's idea in the 1930s. The neutral particle discovered by James Chadwick in 1932 was named neutron. However, neutron was too heavy to be what Pauli predicted.



Walter Baade

The Best of all Explanation

When Albert Einstein came to know about Georges Lemaitre's Big Bang Theory, he exclaimed, "This is the most beautiful and satisfactory explanation of creation to which I have ever listened to".



Enrico Fermi

While developing a theory of weakly interacting particles, Enrico Fermi introduced the name 'neutrino' which means 'little neutral one' for Pauli's particle.

Neutrino is electrically neutral and has a rest mass so negligibly small, it was considered to be zero. Neutrino is smaller than other known elementary particles. As a neutrino abstains from strong interactions, it can pass through normal matter without obstruction and evade detection.

When was superfluidity first defined?

Normally, it takes an effort to make fluids flow. However, this behaviour changes at really low temperatures. In 1937, Russian physicist Pyotr Kapitsa discovered that below -271 degrees Celsius liquid helium loses its resistance to flow. It even exhibits quirky habits such as turning into a thin film and climbing up the walls of its container.

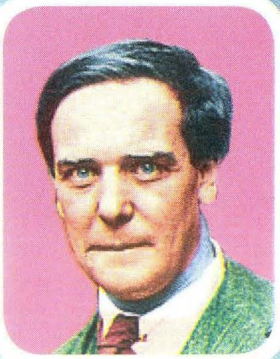
Kapitsa published his findings 1938. Canadian physicist, John Allen, who had discovered it independently, also published his findings the same year.

Superfluidity in helium occurs when helium-3 and helium-4, the two isotopes of helium, are liquefied by cooling to cryogenic temperatures (–150°C to –273 °C). Superfluidity occurs at far higher temperatures in liquid helium-4 than it does in helium-3.

Superfluidity has many applications in astrophysics. Superfluid helium at -271.4 °C was used in a special device in 1983 and many other devices for astronomical observations with infrared sensors.

Shocking Truth

Friction, such as walking on a carpet with stockings on your feet, generates a build-up of electrons that discharge when you touch something with an opposite charge, such as a door handle.



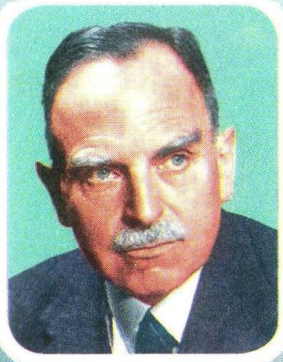
Pyotr Kapitsa

Who were the discoverers of nuclear fission?

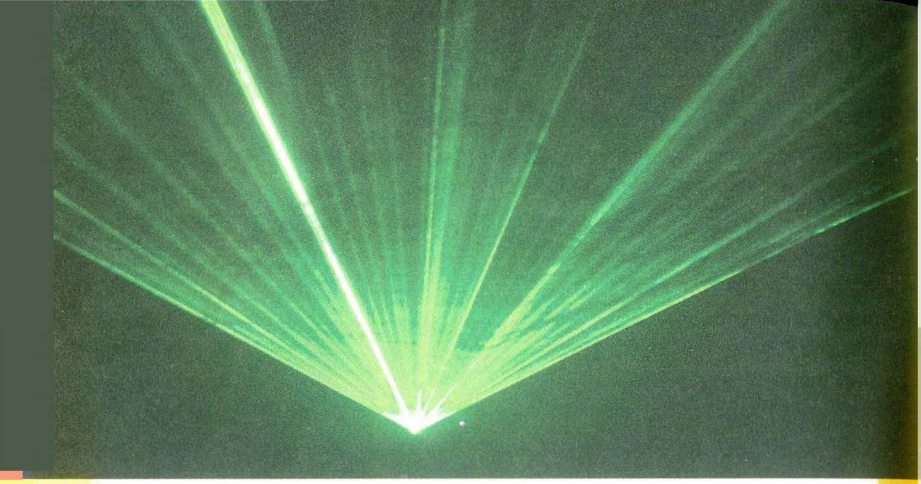
Nuclear fission is the process by which an atom splits into lighter atoms, releasing considerable energy. Its discovery had a substantial effect on energy delivery, geopolitics and advancements in science and medicine.

Bombarding uranium with neutrons causes nuclei of its atoms to split and form lighter elements. German chemists Otto Hahn and Fritz Strassmann discovered this in 1938. But the process was explained and named 'nuclear fission' by Austrian physicists, Lise Meitner and her nephew Otto Frisch. On realising its potential in making bombs, they alerted other physicists who in turn informed the US president. Later, nuclear fission was used in making the atom bombs dropped on Hiroshima and Nagasaki.

Otto Hahn was awarded the Nobel Prize in Chemistry in 1944 for this discovery. Hahn, Meitner and Strassman stood firm against the use of nuclear technologies for military purposes. And they refused to be involved in the development of nuclear weapons though their discovery had made it possible.



Otto Hahn



What is LASER?

The term LASER originated as an acronym for Light Amplification by Stimulated Emission of Radiation.

Absorbing energy excites atoms and molecules. When they are struck by radiation of a suitable frequency, they release their energy as a wave exactly in step with that radiation. Albert Einstein had predicted this stimulated emission in 1917.

In a laser, new radiation strikes other excited atoms, which emit light and lead to a chain reaction. This produces high-intensity radiation with all the waves in step with each other.

Laser light

Laser light is considered pure because it consists of waves of a single frequency, all in step. Laser can be used in instances when light made of jumbled waves of different frequencies is not enough. It can be extremely intense, allowing us to cut metal using it, and narrower than an ordinary beam of light. Lasers are used to make accurate measurements. Their narrow beam is used in surveying to bounce off distant reflectors and give pinpoint positioning. The content in a CD is read by tiny low-powered infrared lasers. Holograms and light shows also make use of lasers.

What is Higgs Boson? When was it discovered?

The Higgs particle is one of the 17 particles in the Standard Model, which is the model of physics describing all known basic particles. Bosons are thought to be particles which are responsible for all physical forces. Higgs particle is a boson and so are photon, W and Z bosons and gluon.

Higgs Boson cannot be easily detected. It does not last long because it is massive when compared to other particles. There are usually no Higgs Bosons around because it takes so much energy to make one. It was mainly for this reason that the Large Hadron Collider at CERN was built.

The existence of Higgs Boson was first suggested by Peter Higgs in the 1960s. Scientists at CERN tentatively confirmed on 14 March 2013 that they had found a Higgs particle.

God Particle

Higgs Bosons which has been featured in an array of science fiction, was called "The God particle" in 1993 by physicist Leon Lederman.

CMS Detector at Large Hadron Collider, CERN

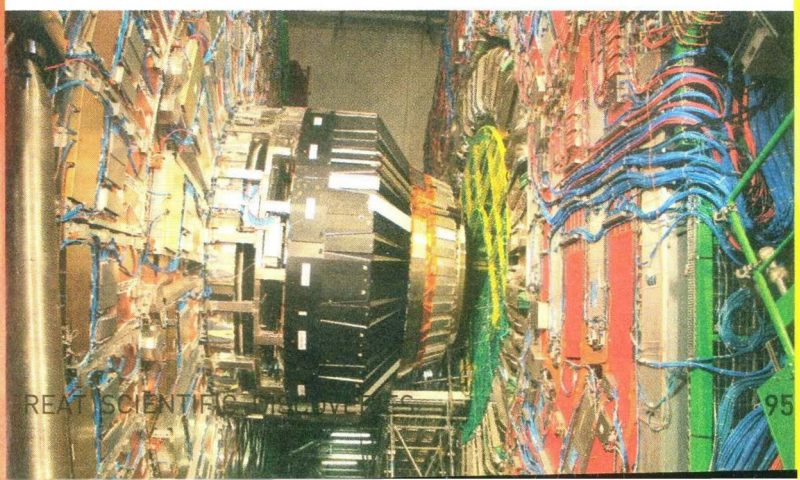


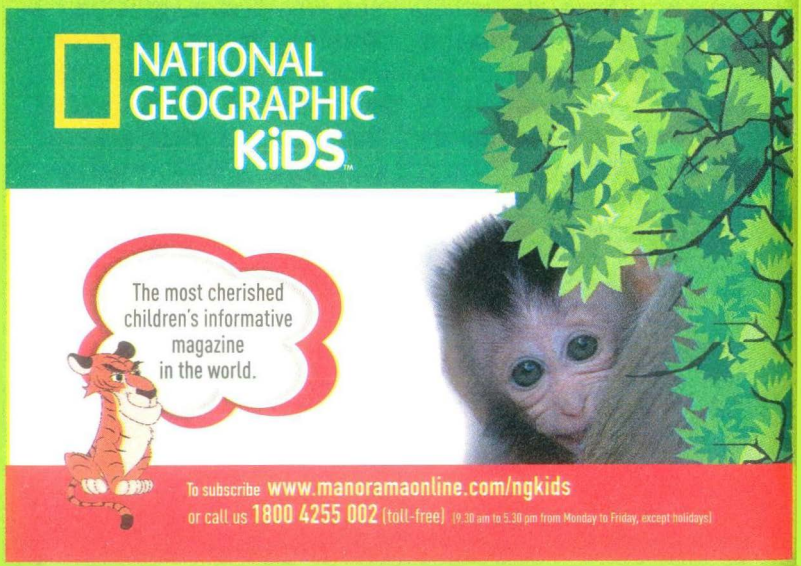
PHOTO QUIZ WINNERS

Winners of the Photo Quiz held in the April issue of Tell Me Why.

1. **Golak Bihari Raj,** Rourkela
2. **K. Baranretharan,** Udumalpet
3. **Mousumi Mandal,** Kolkata
4. **Sreeja Valsan,** Thrissur
5. **M. Sai Karan,** Tirupati
6. **Maitri P. Krishna,** Bengaluru
7. **Aneesh Hebbar , Mijar**
8. **Sneha Vatika,** Aurangabad
9. **R. Shalini,** Chennai
10. **Susanna Joseph,** Trivandrum

Answers:

1. Antarctica 2. Europe 3. Australia 4. Asia 5. Africa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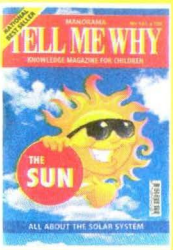

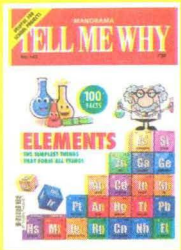

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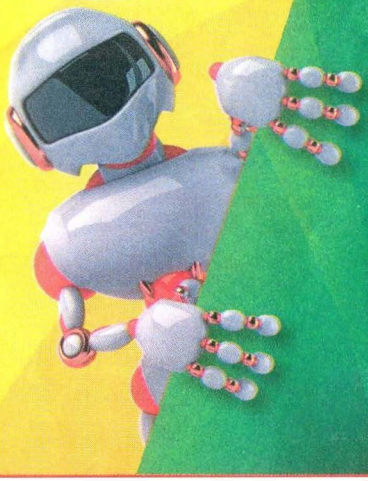

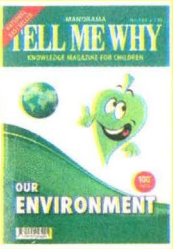

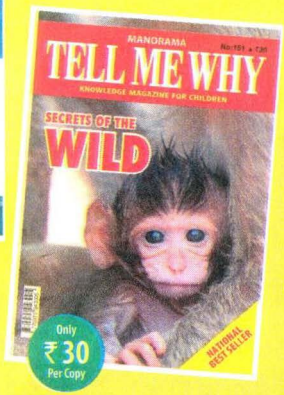

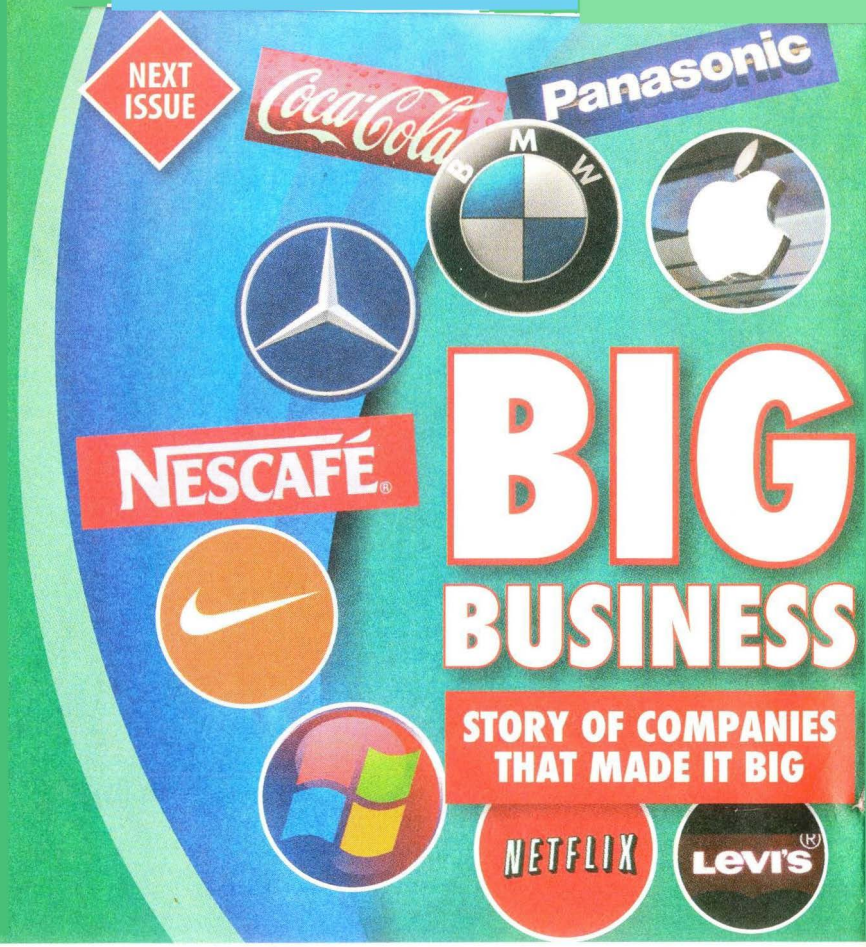
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NETFLIX
Levi's